Volume 15 SEPTEMBER-OCTOBER, 1950 Number 5

Food Research

Under the Editorial Guidance of

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—NICOLAS APPERT.

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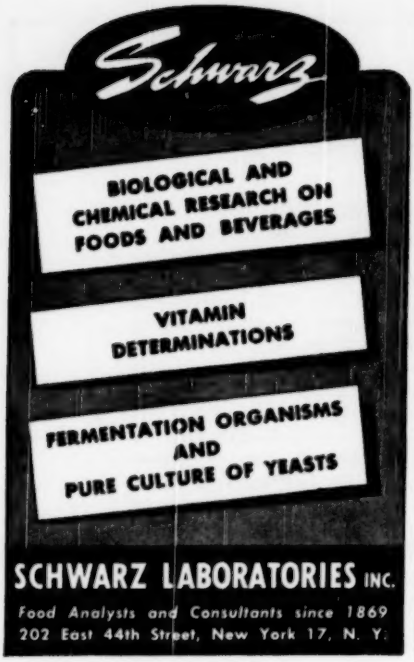
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A PRACTICAL METHOD FOR CONTROLLING ATMOSPHERES FOR USE IN FOOD RESEARCH[1,2,3]

W. S. OGILVY, M. V. BURKE,[4] AND J. C. AYERS[5]
Bacteriology Section, Iowa Agricultural Experiment Station, Ames, Iowa

[Received for publication, November 10, 1949]

Studies involving storage of meat samples under carbon dioxide atmospheres necessitated development of a method which would allow storage of a great many independent samples and yet be economical in regard to handling time, refrigerator space, and cost of equipment. A simple but adequate process has been worked out employing ordinary Mason-type fruit jars. The method is applicable to storage with other gases and vapors and, with atmospheres of nitrogen, has been applied extensively in this laboratory for the enumeration of spore-forming anaerobes in meat samples.

In the form generally used the container consists of a two-quart jar with a No. 12 one-hole stopper (Plate I). The stopper contains a short, bent piece of glass tubing with a piece of rubber pressure tubing attached. A screw clamp on the pressure tubing provides a means of sealing the jar. This type of container affords the the following advantages:

(1) It occupies less space than most other containers used for similar purposes.

(2) It is easily made gas-tight and maintained in that state.

(3) Its initial and replacement costs are low.

(4) It is easily cleaned and readily sterilized by ordinary autoclaving.

(5) It can be adapted to a variety of applications by simple variations in procedure and equipment.

When food samples are to be stored in controlled atmospheres, the following procedure is used: If sterility is desired, the jars are autoclaved. The sample is placed directly on the raised portion of the jar bottom or supported by a wire attached to the rubber stopper. A small amount of distilled water can be added in order to maintain a relative humidity near 100 per cent during storage. Sulfuric acid or salt solutions can be placed in the jar to control humidity when the sample is suspended from the

[1] Appreciation is expressed to Pure Carbonic Company, a division of Air Reduction Co., Inc., New York, New York, for support, in part, of this research.

[2] Also, this paper reports research undertaken, in part, in cooperation with the Quartermaster Food and Container Institute for the Armed Forces, and has been assigned No. 276 in the series of papers approved for publication. The views or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or indorsement of the Department of the Army.

[3] Journal Paper No. J-1710 of the Iowa Agricultural Experiment Station, Ames, Iowa. Projects No. 663 and 1017.

[4] Present address: Tobin Company, Fort Dodge, Iowa.

[5] Present address: Shemical Research and Development, Armour and Company, Chicago, Illinois.

stopper. The atmosphere is adjusted to any definite composition by one of the methods described below, and the jar sealed by means of the screw clamp. Ordinarily, the rubber stopper gives a sufficiently tight seal; in special cases a sealing compound is applied to insure a gas-tight closure. Obviously, a container of this type makes no provision for circulation of the enclosed gases. When circulation is desirable, the equipment can be modified to allow continuous passage of gas of controlled composition through the containers.

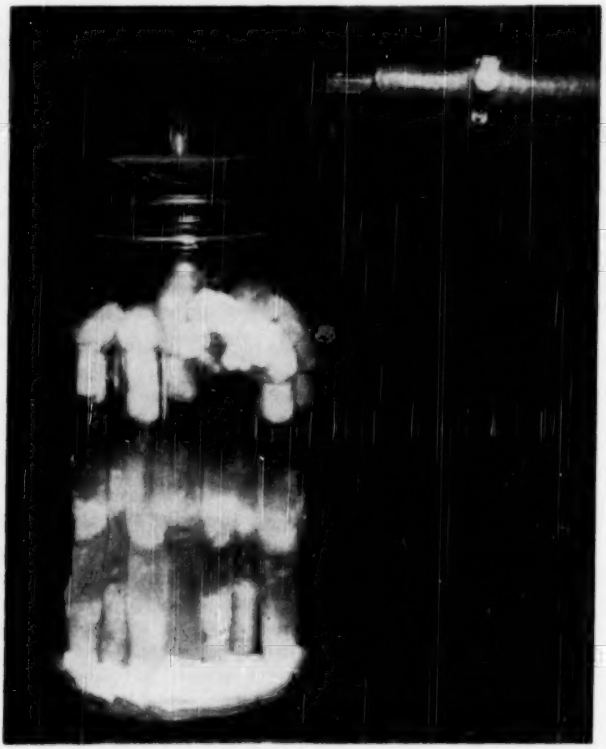

PLATE I. Mason type jar employed for the maintenance of anaerobic conditions.

Two methods were employed for controlling atmospheres. In the first method the composition of the atmosphere of the jar was established by evacuation and subsequent gassing. A jar containing a sample was attached to a glass manifold which in turn was connected to tanks of gas (in our case carbon dioxide and oxygen-free nitrogen), a mercury manometer, a vacuum pump (Cenco Hyvac), and to the air (Fig. 1). After evacuation, sufficient carbon dioxide and air were admitted as determined

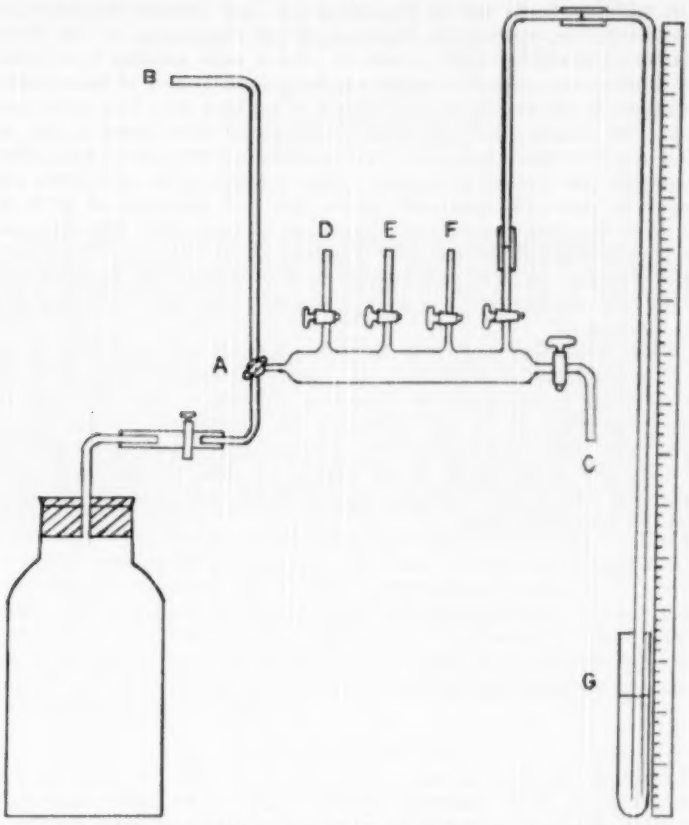

FIG. 1. Apparatus for obtaining controlled atmospheres in storage containers.

A three-way stopcock (A) establishes communication from storage container to gas analyzer (B) or to manifold. A vacuum pump connected to the manifold at (C) permits evacuation of sample jar. Carbon dioxide and oxygen (or other gases) from cylinders and air from the room are admitted to manifold through stopcocks (D, E, F). Mercury manometer (G) is employed to control amounts of individual gases added and to measure vacuums in jars after storage.

with the aid of the manometer to give the final composition desired at atmospheric pressure. The jar was sealed by means of the screw clamp on the pressure tubing and then disconnected.

The second method involved displacement of the air in the jar by a gas mixture of the required composition. The flow rates of the displacement gases were controlled by means of flow meters inserted in the lines from the tanks. In our work the stopper was left ajar and the gas outlet tube was inserted nearly to the bottom of the container. After complete displacement the tube was removed, the stopper pushed into place, and the outlet tube sealed off.

In addition to its use in the storage of food samples in controlled atmospheres, the method has found a special application in the determination of anaerobic spore counts in canned meat samples by a serial tube dilution-most probable numbers technique. A cushion of flannel cloth was placed in the bottom of a two-quart or a gallon jar. Test tubes containing the desired quantities of meat and media were placed in the jar and a tube of reduced methylene blue indicator solution added just before the stopper was pressed into place. (Plate I shows a jar with tubes and stopper in place; two-quart and gallon jars have capacities of 20 to 30 and 45 to 60 tubes, respectively, depending on tube size.) The container was then attached to the manifold described above, evacuated to approximately five-mm. pressure, and brought back to atmospheric pressure with oxygen-free nitrogen. It was again exhausted and filled with nitrogen, then clamped off.

When incubation was to be at higher temperature than that of the room, it was found desirable to keep a somewhat reduced pressure in the jar, in order to minimize the danger of stoppers being forced out by subsequent expansion of the contained gas. After the jar was disconnected, hot Tackiwax was applied to the juncture of the stopper with the jar neck and to the joints in the tubing, in order to insure the maintenance of anaerobic conditions. Upon cooling, this substance formed a solid but non-brittle seal.

MICROBIOLOGICAL OXIDATION OF ETHANOL IN VOLATILE FRUIT CONCENTRATES [1]

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Eastern Regional Research Laboratory,[2]
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[Received for publication, April 10, 1950]

Production of volatile fruit concentrates, or essences, developed at this laboratory, Milleville and Eskew (1944), leads frequently to an accumulation of ethyl alcohol exceeding 0.5 per cent in the distillates, thus making them subject to regulations by the Alcohol Tax Unit.[3]

The problem, therefore, was to remove ethanol—not an essential flavoring agent—from a mixture of many closely related compounds responsible for the characteristic fruit flavor. Of several possible ways to accomplish it, the following were tried: Alcohol precipitants, such as 3,5-dinitrobenzoyl chloride, Lipscomb and Baker (1942), did not give a reaction with ethanol in the extreme dilutions of the experiment. A crude preparation of alcohol dehydrogenase from the sprouts of oats *(Avena sativa)*, Berger and Avery (1943), gave unsatisfactory results because of low activity and instability of the enzyme. A purified alcohol dehydrogenase system could not be considered for commercial use because of the cost. The most promising results were obtained by using the alcohol dehydrogenase contained in *Acetobacter*. In this report, the general principles are established for the treatment of fruit concentrates with resting cells of the bacteria. Many details have to be worked out to make the process commercially feasible, but since the work cannot be continued at present it was thought advisable to present the following preliminary results.

MATERIALS AND METHODS

Apple Essence: The commercial preparation of fruit essence is a two-step process. The juice is flash-vaporized to remove about 10 per cent of the volume, carrying with it substantially all the volatile flavor ingredients. These vapors are then passed to the bottom of a fractionating column, where a further 15-fold concentration results, or 150-fold for both stages. Ordinarily, the vapors from the first step are not condensed. In the present procedure they are condensed, with the idea of so controlling the fold at this stage that the condensate will have less than 0.5 per cent ethanol. This condensate is subjected to the action of *Acetobacter*, and then the product is revaporized and fractionated to complete the second step.

The essence is a colorless aqueous solution of the volatile constituents of natural apple flavor. The flavoring substances comprise from 0.5 to 0.9 per cent of a 150-fold essence. About 24 constituents have been identified,

[1] Report of a study made under the Research and Marketing Act of 1946.

[2] One of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, United States Department of Agriculture.

[3] Federal Register 14, 5869-5879 (1949).

including compounds closely related to ethyl alcohol, such as methanol, propanol, butanol, acetaldehyde, and acetone, White (1950).

Organisms: Several species of *Acetobacter*[4] were found capable of metabolizing ethyl alcohol in extremely low concentrations. *Acetobacter acetosum*, NRRL B-468, and *Acetobacter rancens*, NRRL B-65, produced abundant growth on media containing alcohol as the only source of energy, and the washed bacteria had considerable enzymic activity. But difficulties in collecting and washing the bacteria, with their slow sedimentation rate, necessitated the search for another organism. *Acetobacter aceticum*, NRRL B-43, was selected because of its ability to produce, under certain conditions, sponge-like growth which greatly facilitated its harvesting and separation from the nutrient constituents. In addition, it possessed a sufficiently active alcohol dehydrogenase. Surface membranes of *A. aceticum* are thick and leathery and contain cellulose. The organism closely resembles *Acetobacter xylinum* or is even identical with it.[5]

Culturing A. aceticum: The bacteria were grown with shaking in one-liter Erlenmeyer flasks containing 250 ml. of a medium consisting of 0.5 per cent tryptone, one per cent meat extract, 0.2 per cent sodium chloride, and two per cent glucose. After two days the shake culture served as inoculum for 250-ml. Erlenmeyer flasks with 25 ml. of medium containing three per cent alcohol instead of the glucose. The surface pellicles were allowed to develop undisturbed to a thickness of about five mm., taking four days at 28°C. (82°F.). The leathery membranes were used to inoculate the 10-liter batches of submerged, aerated cultures. A 22-liter round-bottom flask was fitted with a powder funnel, an air outlet, and an air inlet, which ended at the bottom of the flask in a perforated bulb of one-inch diameter. Each flask contained 10 liters of the following medium: one per cent meat extract, 0.5 per cent peptone, 0.2 per cent NaCl, three per cent $CaCO_3$ as marble chips, and, after sterilization, three per cent alcohol. Each flask was inoculated with 20 pellicles of 70-mm. diameter, which were added through the powder funnel. To promote formation of large pieces of connective membranes, the aeration was started slowly and increased after from three to four days, when sponge-like growth was well developed. The cultures were harvested after 10 days, filtered through gauze, and washed three times. For each washing, the membranes were immersed in ice-cold water for one-half hour and filtered off again. A uniform suspension of bacteria was obtained by cutting the connective growth in a Waring Blendor. Aliquot parts of the suspension were taken for dry weights and dehydrogenase determinations. The average yields of *A. aceticum* growth in deep cultures were three gm. of bacteria (dry weight basis) for 10 liters of medium. The rather cumbersome procedure of still cultures in Fernbach flasks, with 250 ml. of medium, produced yields four times larger.

The dehydrogenating ability of the bacteria was determined by the Thunberg technique, with ethanol as substrate and methylene blue as hydrogen acceptor at 30°C.(86°F.) *in vacuo*. Each Thunberg tube contained

[4] Drs. R. W. Jackson and R. T. Milner of the Northern Regional Research Laboratory kindly supplied the cultures of *Acetobacter*.

[5] Dr. R. T. Milner, personal communications.

0.1 M ethyl alcohol, 0.005 M acetate buffer pH 5.6, 0.0001 M methylene blue, and the washed bacteria, in a total volume of 2.5 ml. Average time required to reduce 80 per cent of the methylene blue with different amounts of bacteria is shown (Fig. 1). Direct conclusions from the reduction time of methylene blue to the speed of alcohol oxidation in air or oxygen were not possible, since the rate of dehydrogenation with methylene blue as hydrogen acceptor is considerably lower than with oxygen, and leuko methylene blue exhibits an inhibitory effect, Wieland and Bertha (1928). But the method provided sufficient information about the relative strength of alcohol dehydrogenase in resting cells of *Acetobacter* to serve as a guide for the application of an appropriate amount of bacteria in the oxidation process.

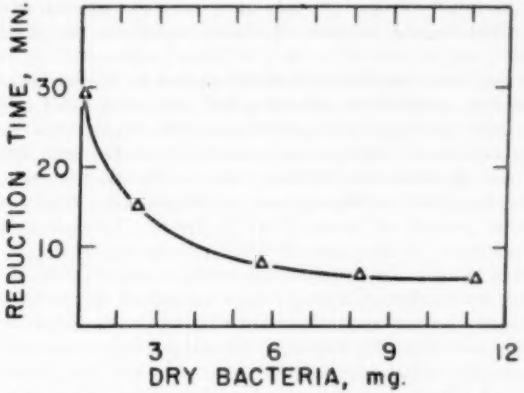

FIG. 1. Alcohol dehydrogenase activity of *A. aceticum* as determined by the time required to reduce 80 per cent of methylene blue at 30°C. (86°F.) in the presence of ethyl alcohol and different amounts of bacteria.

Washed bacteria were used for the alcohol oxidation to prevent introduction of foreign and off-flavor substances in the essence. Though the chosen species of *Acetobacter* should be capable of oxidizing ethanol to completion, that is, to carbon dioxide and water, the resting bacteria carried dehydrogenation only to the acetic acid stage under the conditions of the experiment. Addition of nicotinic acid, Kligler and Grossowicz (1941), or pyruvate, Tosic (1946), had no favorable influence on the acetate oxidation. Since aqueous or saline suspensions of the resting cells did not maintain full dehydrogenase activity for 24 hours, most of them were used immediately. If storage was unavoidable, they were centrifuged, frozen, and kept at —22°C. (—8°F.), with little loss of activity. No attempt was made to separate the enzyme system from the cells.

Alcohol Oxidation and Essence Treatment: To study the optimal conditions for the treatment of apple essence with bacteria, a mixture was prepared which simulated the composition of a possible condensate obtained in the first step in the production of essence, Milleville and Eskew (1944). The aqueous solution contained a 10-fold essence, three per cent apple juice,

and 0.4 per cent ethyl alcohol. It was necessary to conduct the oxidation in a close system, to minimize loss of the highly volatile flavor constituents. The volume of oxygen thus required was empirically determined to be five times the amount calculated for oxidation of ethanol to acetic acid. The operation finally adopted was as follows: Two-liter jars were each filled with 200 ml. of the oxidation mixture, which contained the washed bacteria and had been adjusted to the pH optimum (5.6) of the bacterial alcohol dehydrogenase. The jars were filled with oxygen, tightly sealed, and shaken at 30°C. (86°F.) with a speed of 90 strokes per minute. Before opening, they were cooled to 4°C. (39°F.) to prevent loss of essence.

Simpler procedures in open systems, such as blowing air through the oxidation mixture in the presence of the bacteria, or a continuous process similar to the quick vinegar process, gave excellent alcohol oxidation but had to be discontinued because of almost complete loss of the volatile constituents.

After it had been established that the essence in no way interfered with alcohol oxidation, a solution containing 0.4 per cent alcohol and three per cent apple juice was used for most experiments undertaken to determine the limiting amount of bacteria and time required for complete oxidation. To detect how the organoleptic properties of the essence are affected by the bacterial treatment, rather extreme conditions were chosen, with excessive oxidation periods of from 15 to 20 hours. To operate the essence recovery apparatus, a minimum of four gallons was required. Since for technical reasons only small volumes could be handled in the dehydrogenation process, 20- to 40-fold essences were submitted to the bacterial treatment and then diluted to a theoretical one-fold concentration with tap water, thus providing the required volume for the recovery unit. The oxidized material, with a pronounced odor of acetic acid, was neutralized to pH five and filtered, and the essence recovery procedure was carried out under the following conditions: Input rate of five gallons per hour, 10 per cent vaporization, and final concentration ratio of 100 to one (100-fold). The controls, consisting of one-fold solutions of untreated (alcohol-containing) essence, were submitted to the same concentration process.

Alcohol Determinations: At the beginning of this work, alcohol determinations were made by a specific gravity method adopted from the Association of Official Agricultural Chemists' Book of Methods, Sixth Edition, Paragraphs 15.4, 16.47, and 16.6. The method involved distillation, followed by measurement of specific gravity when no essence was present; salting, extraction with petroleum ether, and distillation of the aqueous alcoholic salt solution, followed by measurement of specific gravity when essence was present. When applied to solutions containing 0.40 per cent ethanol plus three per cent apple juice, this method gave an average value of 0.36 per cent, with a standard deviation of 0.11 per cent ethanol.

It was desirable to develop a method of greater precision for measuring low ethanol concentrations. Determinations of the refractive indices of the alcoholic solutions on a differential refractometer gave consistent results if certain precautions were observed in preparation of the samples. The differential refractometer, Brice and Speiser (1946), measures difference in refractive index directly with a limiting sensitivity of about 3×10^{-6}.

Because of its high sensitivity and its relative insensitivity to temperature change, it is much better suited to determination of ethanol in water, in the concentration range of 0.5 per cent or less, than the dipping or Abbé types of refractometer. The instrument was calibrated with standard solutions of from 0.5 to 0.05 per cent ethanol in water. Results of the measurements were precise to ± 0.01 per cent ethanol.

To prepare samples for the refractometer readings, 25 or 50 ml. of the oxidation mixture were adjusted to pH eight and distilled at the slow rate of 25 ml. per hour until almost the entire initial volume had been collected, the exact volume being restored by addition of water. A faster distillation resulted in slightly turbid solutions which could not be cleared and which were unsuited for the refractive index determinations. Since the essence and bacterial metabolites gave refractive indices of their own, they were compensated for by controls containing bacteria, essence, and apple juice, but no alcohol. The control samples were submitted to the oxidation procedure, then distilled, and the distillates measured in the differential refractometer. The difference beetween the values thus obtained for the samples and the corresponding controls was the apparent alcohol content of the sample. Comparable results were obtained either by using one half-cell of the apparatus for the sample and the other half-cell for the control, or by computing the readings of both sample and control against solvent.

RESULTS

Data obtained by the differential refractive index method made it possible to record the oxidation progress clearly and accurately (Table 1 and Fig. 2). Linearity of dehydrogenation versus time extended to about 75 per cent oxidation. Removal of the last 25 per cent of ethanol proceeded at an increasingly slower rate, requiring another two hours in the presence of an approximate one per cent bacterial suspension.

The active alcohol dehydrogenase content of *Acetobacter aceticum*, grown in deep or still cultures, varied little, following in general the curve given (Fig. 1). Resting bacteria of average activity, in one per cent concentration (on dry weight basis), completed the oxidation of 0.4 per

TABLE 1

Oxidation of 0.4 Per Cent Ethanol Solutions by A. aceticum in Closed Systems Under Oxygen at 30°C. (86°F.)[1]

Time of oxidation	Dry weight of bacteria	Essence present	Ethanol after oxidation
hr.	*pct.*		*pct.*
0.25	0.8	none	0.35
0.5	0.8	none	0.31
1	0.8	none	0.25
2	0.8	none	0.11
2	1.1	none	0.09
3	1.1	none	0.02
4	1.1	none	0.00
5	1.1	none	0.00
5	0.6	30-fold	0.00
16	0.6	30-fold	0.00

[1] Alcohol determinations by differential refractometer.

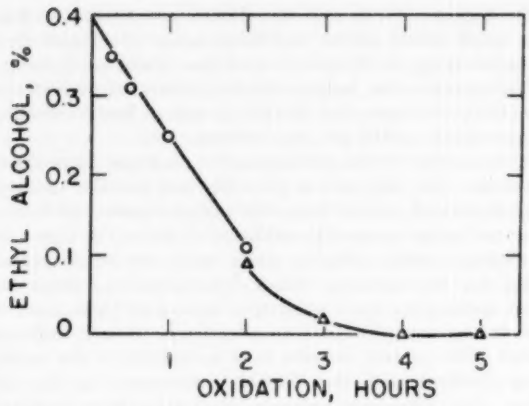

FIG. 2. Progress of oxidation of a 0.4 per cent ethanol solution by *A. aceticum* at 30°C. (86°F.)
O in presence of 0.8 per cent (dry weight) of bacteria.
Δ in presence of 1.1 per cent (dry weight) of bacteria.

cent ethanol solutions in four hours. Smaller amounts of bacteria may be used by extending the time of contact with the oxidation mixture. Possibly the same cells could be used twice. But exceedingly prolonged shaking of the essence at 30°C. (86°F.), even without bacteria, impaired the "freshness" in the aroma of the apple essence.

The essence, even in high concentrations, did not alter the enzymic activity. A 0.6 per cent bacterial suspension removed the alcohol completely in five hours from a 0.4 per cent ethanol solution, in the presence of 30-fold essence.

For optimal conditions of flavor retention, six to 10 gm. of bacteria should be used for one liter of essence of any concentration containing 0.4 per cent ethanol, over a contact period of from four to six hours. These proportions would require the growth of 20 liters of aerated cultures, or five liters of still cultures.

The recovered essences, of both treated samples and controls, were compared in respect to their concentrations and flavor changes. The concentration was judged by ascertaining the highest dilution at which the characteristic aroma was still detectable. Recovered essences from the bacteria-treated samples were of 45- and 41-fold concentrations, whereas strength of the control after essence recovery was 74-fold. This loss of about 40 per cent could probably be greatly reduced by using shorter oxidation periods and enlarging the facilities for the dehydrogenation process.

The over-all rating as to quality was obtained by adding the essences on the basis of their tested fold, to essence-free concentrated apple juice, Griffin, Talley, and Heller (1947). The reconstituted juices, containing either treated or control essences, were submitted to a taste panel of about 10 people. Flavor qualities were rated on a scale of one to 10, 10 repre-

senting excellent, and one an objectionable, flavor, Heller, Nold, and Willaman (1947, 1949). The alcohol-free essences received ratings of 6.1 and 5.9 against 7.3 and 6.8 for the controls. No odor of acetic acid was detectable in the treated products. Thus, both methods of evaluation indicate a loss of essence during the process as a whole.

CONCLUSIONS

It can be concluded that ethyl alcohol in concentrations below 0.4 per cent can be removed from apple essence by resting cells of *Acetobacter*. It does not seem, however, that the process would be commercially feasible in its present state of development. Rather large volumes of culture are required to furnish the bacterial cells for treating smaller volumes of essence. The time for treatment is several hours. There is some loss of essence. Now that the general principles are established, however, it is possible that more efficient details could be worked out, such as a more prolific or more active species of *Acetobacter*, a better medium, use of the cells a second or third time, more effective conditions for the oxidation of the alcohol, and reduction of the loss of essence.

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SUMMARY

Resting cells of *Acetobacter aceticum* are capable of removing ethyl alcohol from mixtures of chemically related substances. This property has been utilized for its elimination from volatile fruit concentrates. Apple essence of 20- to 40-fold concentration, containing 0.4 per cent ethanol, was freed of the alcohol by treatment with 0.6 to one per cent bacteria (dry weight basis) in a closed system under oxygen for from four to six hours.

The procedure caused some loss of volatile constituents but did not impair the character of the flavor. The same method could no doubt be used on any other volatile fruit concentrate.

A method is described in which a differential refractometer is used for ethyl alcohol determinations in concentrations of 0.5 per cent or less with a precision of 0.01 per cent.

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COMPOSITION OF FOOD PLANTS OF CENTRAL AMERICA. V. NICARAGUA

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This report is the fifth in a series covering results from a study begun in 1946 to obtain data on the composition of food plants found growing in the several countries of Central America. In the first four papers data were given for 121 samples from Honduras, Munsell, Williams, Guild, Troescher, Nightingale, and Harris (1949); 230 samples from Guatemala, Munsell, Williams, Guild, Troescher, Nightingale, and Harris (1950a and 1950b); and 194 samples from El Salvador, Munsell, Williams, Guild, Troescher, Nightingale, Kelley, and Harris (1950c). The data obtained for a number of foods indicated they had exceptionally high nutritive values and could make significant contributions to the nutritive value of the diet.

Results from analyses of 51 samples collected in Nicaragua in November, 1946, and of four samples shipped from Panama, are shown in the present report. The samples from Nicaragua included 40 of fresh foods, 10 of dry cereals and legumes, and one classified as miscellaneous; those from Panama, three of citrus fruits and one of a nut.

The fresh samples were stabilized by the procedure already described, Munsell *et al.* (1949), and shipped by air express to Cambridge, where the analytical work was done. Two slurries only were made of each sample at this time of the study. Subsamples of the citrus fruits from Panama were stabilized in Honduras for final shipment. The dry samples were packed in tight metal containers for shipment.

The same constituents were measured as shown in the preceding reports and methods of analyses used were the same as described in the first paper, Munsel *et al.* (1949), except for the determination of ascorbic acid in the three samples of citrus fruits from Panama. For these analyses the modified method described in the second report, Munsell *et al.* (1950a), was used.

Values obtained from the analyses and the places of origin of the samples are shown (Table 1). The majority of samples from Nicaragua originated in the western coastal-to-highland area, where the altitude ranges from 200 to 2,000 feet and the soil is predominantly volcanic. No estimates of the annual rainfall were obtained. All except three of the samples were purchased in markets or local stores. These three samples, *ayote*, *sandía*, and *zapote amarillo*, were taken directly from plants. The 51 samples from Nicaragua represent 42 foods; there were more than one sample for only four of these.

TABLE 1

Composition of Food Samples From Nicaragua and Panama

Name of food sampled			Place of origin of samples	Constituents measured and yields per 100 gm.												
Spanish	Scientific	English		Moisture	Ether extract	Crude fiber	Nitrogen	Ash	Calcium	Phosphorus	Iron	Carotene	Thiamine	Riboflavin	Niacin	Ascorbic Acid Total
	EARTH VEGETABLES			*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*
Camote	*Ipomoea Batatas* (L.) Lam.	Sweet potato	Masaya	65.0	0.14	1.0	0.145	.96	16.6	31.0	0.83	.008	.133	.022	.553	26.2
Cebolla	*Allium Cepa* L.	Onion	Department Segovia	84.4	0.13	0.6	0.297	.56	18.7	55.8	0.81	.000	.051	.021	.263	4.8
Papa	*Solanum tuberosum* L.	Potato	Matagalpa	75.9	0.04	0.5	0.320	.93	2.0	41.5	0.38	.006	.111	.019	1.460	17.0
Rábano	*Raphanus sativus* L.	Radish	Matagalpa	94.8	0.08	0.6	0.146	.77	21.4	21.7	1.17	.005	.019	.022	.392	26.4
Remolacha	*Beta vulgaris* var. *crassa* Alef.	Beet	Managua	88.7	0.12	0.7	0.275	1.24	16.5	49.0	0.66	.003	.005	.036	.384	4.3
Tisquisque	*Xanthosoma violaceum* Schott	a yautia	Masaya	67.5	0.16	0.6	0.193	1.24	7.4	61.7	1.21	.004	.112	.017	.585	7.4
Yuca	*Manihot esculenta* Crantz	Cassava	Masaya	67.8	0.11	1.4	0.276	.92	48.6	51.7	2.04	.002	.090	.034	.850	33.5
Zanahoria	*Daucus Carota* L.	Carrot	Managua	91.7	0.11	0.8	0.190	1.21	34.3	66.8	1.49	1.472	.053	.031	.979	7.9
	HERBAGE VEGETABLES															
Colinabo	*Brassica caulorapa* (DC.) Pasq.	Kohlrabi	Managua	91.6	0.11	0.7	0.303	1.01	29.7	61.7	0.42	.006	.042	.027	.431	76.6
Lechuga	*Lactuca sativa* var. *Romana* Hort.	Lettuce	Managua	95.2	0.22	0.5	0.222	.86	51.4	28.4	3.06	.226	.058	.082	.463	12.4
Repollo	*Brassica oleracea* var. *capitata* L.	Cabbage	Matagalpa	93.8	0.28	0.6	0.128	.42	44.2	19.4	0.50	.004	.025	.025	.160	28.2
	FRUIT VEGETABLES															
Aguacate	*Persea americana* Mill.	Avocado	Department Chinandega	79.9	11.86	1.4	0.130	.72	9.8	37.4	0.61	.130	.041	.065	1.253	14.7
Ayote	*Cucurbita Pepo* L.	Pumpkin	Granada	92.3	0.06	0.5	0.103	.43	9.8	19.3	0.56	.048	.035	.016	.436	10.8
Berengena	*Solanum Melongena* var. *esculentum* (Dunal) Nees.	Eggplant	León	93.8	0.11	0.5	0.150	.43	5.4	24.2	0.45	.002	.045	.030	.568	4.3
Chayote	*Sechium edule* (Jacq.) Sw.	Chayote	Masatepe	93.3	0.15	0.5	0.143	.36	14.1	27.4	0.50	.001	.019	.021	.414	12.6
Chile dulce	*Capsicum annuum* var. *grossum* (L.) Sendt.	Sweet pepper	Masaya	87.6	0.34	2.4	0.166	.78	4.5	31.6	0.76	.349	.081	.066	.984	147.0
Pepino	*Cucumis sativus* L.	Cucumber	Niquinhomo	95.5	0.17	0.6	0.110	.46	7.4	33.0	0.47	.002	.032	.019	.212	12.3
Pipián	*Cucurbita Pepo* L.	Summer squash	Managua	94.0	0.20	0.3	0.178	.58	21.5	44.0	0.98	.017	.041	.038	.624	18.4
Tomate	*Lycopersicum esculentum* Mill.	Tomato	Masaya	94.3	0.13	0.6	0.115	.52	4.7	23.6	0.84	.253	.068	.029	.528	18.4

CEREALS														
Elote	*Zea Mays* L.	Green corn	Masaya	63.3	1.01	0.9	0.746	.80	3.4	127.0	1.05	.007	.176	.078	1.910	6.4
Jilote	*Zea Mays* L.	Green corn	Managua	89.4	0.23	0.6	0.265	.71	9.1	62.7	.45	.003	.080	.073	.656	10.0
LEGUMES														
Frijolito	*Phaseolus vulgaris* L.	Snap bean	Jocote Grande	91.6	0.21	1.0	0.301	.61	51.8	39.2	1.51	.141	.067	.107	.648	10.8
Frijolito	*Vigna unguiculata* (L.) Walp.	Cowpea	Managua	88.5	0.34	1.2	0.506	.65	36.1	58.3	1.61	.376	.095	.106	1.029	18.0
FRUITS														
1. Citrus														
Limón	*Citrus Limon* (L.) Burm. f.	Lemon	Panama	91.4	<0.01	0.2	0.042	.15	10.4	9.4	0.69	.014	.013	.010	.056	24.9
Limón dulce	*Citrus limetta* Risso	.....	Granada	89.3	0.10	0.7	0.162	.43	28.6	21.6	0.53	.005	.030	.025	.177	44.4
Mandarina	*Citrus reticulata* Blanco	Tangerine	Matagalpa	90.2	0.10	0.4	0.117	.36	23.6	15.0	0.62	.152	.071	.021	.200	23.2
Naranja (a)	*Citrus sinensis* (L.) Osbeck	Orange	Matagalpa	85.9	0.02	0.5	0.090	.37	25.5	19.0	0.39	.009	.086	.021	.231	56.4
Naranja (b)	*Citrus sinensis* (L.) Osbeck	Orange	Panama	91.1	0.22	<0.01	0.049	.30	8.9	11.1	0.30	.016	.048	.009	.104	55.0
Toronja (a)	*Citrus maxima* (Burm.) Merrill	Grapefruit	Matagalpa	87.5	0.07	0.4	0.101	.47	27.1	47.9	0.70	.005	.057	.015	.223	47.6
Toronja (b)	*Citrus maxima* (Burm.) Merrill	Grapefruit	Panama	90.4	0.20	0.1	0.116	.28	20.2	21.0	0.41	.013	.051	.017	.198	39.3
2. Bananas and plantains														
Banano manzano	*Musa paradisiaca* var. *sapientum* L.	Apple banana	Masaya	68.2	0.13	0.3	0.177	.71	1.3	28.9	0.56	.013	.042	.019	.600	13.6
Maduro	*Musa paradisiaca* L.	Plantain	Jinotepe	62.0	0.14	0.3	0.150	.75	1.4	42.7	0.77	.168	.059	.025	.560	12.6
Plátano cuadrado	*Musa paradisiaca* L.	Plantain	Rivas	69.9	0.14	0.3	0.171	.73	4.5	43.5	0.85	.015	.050	.027	.544	18.2
3. Other fruits														
Cojombro	*Sicana odorifera* (Vell.) Naud.	.....	Masatepe	92.7	0.21	0.6	0.093	.38	8.2	24.2	0.87	.003	.038	.026	.647	10.0
Coyolito	*Bactris minor* Jacq.	.....	Department Chontales	77.3	0.33	2.7	0.130	.87	4.0	23.9	0.88	.036	.025	.057	.430	10.3
Guayaba	*Psidium guajava* L.	Guava	Masaya	83.2	0.70	5.0	0.244	.95	14.0	36.9	0.82	.028	.036	.032	2.320	64.0
Mamón	*Melicocca bijuga* L.	.....	Masaya	68.8	0.30	2.2	0.391	.74	9.4	50.4	0.93	.020	.016	.016	.780	10.0
Mimbro	*Averrhoa Bilimbi* L.	.....	Granada	94.2	0.12	0.6	0.117	.31	3.4	11.1	1.01	.035	.010	.026	.302	15.5

TABLE 1 *(Concluded)*

Composition of Food Samples From Nicaragua and Panama

Name of food sampled			Place of origin of samples	Constituents measured and yields per 100 gm.												
Spanish	Scientific	English		Moisture	Ether extract	Crude fiber	Nitrogen	Ash	Calcium	Phosphorus	Iron	Carotene	Thiamine	Riboflavin	Niacin	Ascorbic Acid Total
				gm.	gm.	gm.	gm.	gm.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
Nispero	*Achras Zapota* L.	Sapodilla	Rivas	75.9	0.36	1.1	0.075	.41	13.3	6.7	0.83	.013	.002	.003	.286	8.2
Piña	*Ananas comosus* (L.) Merrill	Pineapple	Managua	90.3	0.10	0.4	0.080	.49	28.4	11.9	0.68	.003	.049	.022	.126	43.2
Sandía	*Citrullus vulgaris* Schrad.	Watermelon	Granada	94.7	0.18	0.1	0.068	.23	4.8	8.2	0.63	.028	.018	.012	.120	3.4
Zapote	*Calocarpum mammosum* (L.) Pierre	Sapote	Rivas	62.9	0.15	1.4	0.326	1.26	44.7	33.1	2.62	.518	.008	.030	2.448	40.0
Zapote amarillo	*Pouteria campechiana* (HBK.) Baehni	.....	Diriamba	58.3	0.26	1.7	0.263	.91	24.6	55.2	1.27	2.630	.022	.028	5.250	59.5
	DRY SAMPLES															
	1. Cereals															
Arroz	*Oryza sativa* L.	Rice	Diriamba	9.1	0.77	0.1	1.360	.47	6.2	113.0	1.82	.000	.066	.021	1.509	.....
Maíz	*Zea Mays* L.	Corn	Department Chinandega	10.6	5.30	1.3	1.595	1.27	6.3	286.8	2.15	.012	.459	.052	2.440	.....
Maíz	*Zea Mays* L.	Corn	Managua	10.3	5.83	1.2	1.771	1.56	7.9	359.0	2.67	.004	.452	.074	2.913	.....
	2. Legumes															
Frijol	*Phaseolus vulgaris* L.	Bean	Matagalpa	11.8	2.27	3.7	3.730	3.70	106.8	452.5	7.18	.017	.090	.135	2.169	.....
Frijol bayo (a)	*Phaseolus vulgaris* L.	Bean	Diriamba	11.0	2.44	4.2	3.665	3.55	79.3	412.0	8.12	.018	.105	.138	1.839	.....
Frijol bayo (b)	*Phaseolus vulgaris* L.	Bean	Matagalpa	11.2	2.49	3.7	3.125	3.61	114.1	385.0	7.15	.024	.116	.142	2.590	.....
Frijol bayo (c)	*Phaseolus vulgaris* L.	Bean	Matagalpa	12.3	2.64	4.1	3.870	4.08	136.3	492.5	7.73	.020	.123	.178	1.992	.....
Frijol blanco	*Phaseolus vulgaris* L.	Bean	Department Chinandega	10.6	2.22	3.2	3.915	3.35	97.9	332.0	8.22	.013	.377	.103	2.380	.....
Frijol dulce	*Phaseolus vulgaris* L.	Bean	Diriamba	8.7	2.95	3.3	4.095	3.30	118.6	308.0	8.83	.007	.383	.115	2.893	.....
Frijol rojo	*Phaseolus vulgaris* L.	Bean	Diriamba	10.7	2.45	4.2	3.608	3.61	135.0	396.0	7.94	.026	.185	.137	1.831	.....
	3. Miscellaneous															
Cacao	*Theobroma Cacao* L.	Cacao	Department Rivas	3.3	41.70	15.3	2.145	2.95	138.9	453.0	2.89	.034	.114	.103	1.359	.....
.....	*Canarium ovatum* Engler	Pili nut	Panama	14.2	62.79	2.0	2.013	3.10	154.1	60.7	4.14	.039	.639	.064	.468	21.1

DESCRIPTIONS AND USES OF FOODS STUDIED [1]

EARTH VEGETABLES:

Camote (I, *Camote*). The sweet potato is apparently of American origin and has been in cultivation since pre-Columbian times. It is cooked in various ways but not used as commonly as it might be. The sample was made up of eight ripe tubers having purple-red skins and white flesh. These were peeled and quartered for subsampling.

Cebolla. The common onion is one of the oldest of the food plants and has been in cultivation 4,000 or more years. The place of origin is not known, other than that it was in the Old World, possibly in southern Asia or in the Mediterranean area. The onion is the principal food plant in which the food is stored in a bulb. Onions are exceedingly expensive in Nicaragua and probably little used, and then most commonly as flavoring.

Papa (I, *Papa*). In Nicaragua the best potatoes are produced in the vicinity of Matagalpa. The sample comprised 14 mature potatoes of a white-skinned variety. These were peeled and quartered for subsampling.

Rábano (I, *Rábano*). The cultivation of radishes goes well back into antiquity. They probably originated in western Asia. The 23 large roots that made up the sample had red skins and white flesh. Skin and flesh were included in the subsamples.

Remolacha. The beet has been in cultivation at least 2,000 years and without doubt was derived from the wild beet of the Mediterranean regions. It is expensive and not too popular as a food in Nicaragua. The sample consisted of 36 small roots. Flesh only was included in the subsample.

Tisquisque (I, *Malanga*). The Xanthosomas are difficult to distinguish one from another and, as a matter of fact, there may be only one species in cultivation in Central America. The roots are almost indistinguishable from those of the taros, but the plants may be easily differentiated by the leaf. The sample comprised 12 mature roots. These were peeled and quarterings made for the prepared samples.

Yuca (I, *Yuca*). Cassava is native to America, probably Brazil, and is now an important food plant in the tropics of the world. In Nicaragua it is used commonly as a cooked vegetable. Twelve long, slender, mature roots made up the sample. These were peeled and quartered for subsampling.

Zanahoria. Carrots have been cultivated for more than 2,000 years and were brought to America in the 17th century. The sample consisted of 12 small carrots weighing about one pound. These cost 36 cents. At this price it may be assumed that carrots are not used extensively in Managua. For subsampling the roots were washed but not peeled.

HERBAGE VEGETABLES:

Colinabo (I, *Colinabo*). The sample of kohlrabi consisted of 20 pale-green stems. These were peeled for subsampling.

[1] A description of some of the foods has already been given in earlier reports. A notation in parentheses, following the name of the food, gives the series number of the report and the name of the food under which this will be found: I, Munsell *et al.* (1949); II, Munsell *et al.* (1950a); III, Munsell *et al.* (1950b); and IV, Munsell *et al.* (1950c).

Lechuga (II, *Lechuga*). Lettuce is eaten as a salad, green and also cooked, and in soups. It is very expensive in Nicaragua and little of it is seen in the markets. The sample was all of the one lot found and cost one dollar for about one and one-quarter pounds.

Repollo (I, *Repollo*). Cabbages, of which there are some 500 horticultural forms in cultivation, are one of the most important of the cultivated vegetables; their cultivation is exceedingly ancient. Five small green, mature heads made up the sample.

FRUIT VEGETABLES:

Aguacate (I, *Aguacate*). The sample consisted of six fruits that appeared to be of the Guatemalan race, having thick skins and moist flesh. The flesh was mixed for subsampling.

Ayote (I, *Ayote*). *Cucurbita Pepo* is undoubtedly of American origin and has been in cultivation for a very long time. It was undoubtedly one of the basic food plants of the ancient American civilizations. The four ripe pumpkins for the sample were taken from plants and were of the hardshelled variety with yellow, moist flesh. Flesh only was used in the subsamples for analysis.

Berengena (I, *Berengena*). The eggplant, possibly native to India, is of rather ancient cultivation although it has spread only in recent times. Eight medium-size fruits were purchased for the sample. These were immature but ready to eat. Pulp only was used in the subsample.

Chayote (I, *Pataste*). The sample consisted of 12 fruits of the spineless variety, with green skins, and mature enough to eat. These were quartered for subsampling.

Chile dulce (I, *Chile dulce*). *Capsicum annuum* is probably of American origin, perhaps Brazilian. The present variety is the plant commonly known as sweet pepper. The sample comprised 72 small fruits, some green and some red. Seeds were discarded in preparing the subsamples.

Pepino (I, *Pepino*). The cucumber, native to India, has been in cultivation 3,000 years or more and is now cultivated throughout the temperate and tropical parts of the world. Six large, nearly ripe fruits made up the sample. The fruits were peeled for subsampling.

Pipián (I and present report, *Ayote*). Seven small tender squashes at the right stage to eat were purchased for the sample. The skins of these were tender and easily bruised, the flesh was faint-yellow, and the peel pale-green. The fruits were quartered and pulp and seed used in the subsamples.

Tomate. The tomato is of New World origin and may have originated in western South America as a cultigen. There is no evidence that the tomato as we know it is to be found anywhere as a wild plant. It well may have originated from the cherry tomato [*Lycopersicum esculentum* var. *cerasiforme* (Dunal) Hort.] which is to be found, naturalized or as a weed, in cultivated lands in much of tropical America. The sample consisted of 12 small, ripe tomatoes. Skin and pulp were used in the subsamples.

LEGUMES:

Frijolito (I, *Habichuela*). The sample consisted of fresh, tender green beans. Whole pods were used in the subsamples.

Frijolito (I, *Frijol de vaca*). The cowpea or black-eyed pea is native to tropical Asia and is now widely cultivated in tropical and subtropical regions. In Nicaragua the green pods are prepared by boiling and then frying in fat. Whole legumes that were tender and green were used in the prepared samples.

CEREALS:

Elote (I, *Jilote*). Twelve cobs of fresh green corn in the dough stage were purchased for the sample. These were of the white kerneled variety, a kind used for tortillas. The kernels only, cut from the cob, were used in the subsamples.

Jilote (I, *Jilote*). The sample consisted of 60 ears of very young corn. At this stage the entire cob with kernels is used in soups and stews, or as a boiled vegetable. The whole cob was used in the subsamples.

FRUITS:

CITRUS:

Limón (I, *Limón*). Lemons have been cultivated since very ancient times and probably had their origin in southeast Asia. This sample from Panama consisted of 20 small fruits with yellow skins and pale-greenish-yellow flesh that was quite acid. Juice only, expressed by hand, was used for subsampling.

Limón dulce (I, *Lima limón*). Twelve fruits of about 150 gm. each were purchased for the sample. Pulp and juice were used in the subsamples.

Mandarina (I, *Mandarina*). The sample consisted of 12 mature, juicy fruits. All except the peel was used in the subsamples for analysis.

Naranja (III, *Naranja*). The sweet orange is native to southeast Asia, probably China, and has been in cultivation for more than 3,000 years. It was brought to Europe about 500 years ago and from there to the New World. Sample (a) from Nicaragua comprised 16 small, ripe fruits of the variety common in the market at the time of purchase (November). Pulp and juice were used in the subsamples. Sample (b) from Panama consisted of 12 small, ripe fruits with pale flesh. These were rather sweet but not of too good flavor. Juice only, hand expressed, was used in the subsamples.

Toronja. The grapefruit probably originated in cultivation and possibly in more than one place. It has been grown for a long time in the western hemisphere but, until recently, primarily for decorative purposes rather than for its fruit. Sample (a) was from Nicaragua and consisted of 12 fruits of about 400 gm. each. These were small but quite good. Juice and pulp were used in the samples for analysis. Sample (b) from Panama consisted of six fruits. These were of rather poor quality. The flesh was pale and rather bitter. The edible pulp, removed with a sharp knife, was used in the subsamples.

BANANAS:

Banano (I, *Banano*). The banana, native to India or Malaya, is of ancient culture and is found throughout the tropics of the world where the climate will permit its growth. One dozen ripe fruits were purchased for the sample.

Maduro and *plátano* (I, *Plátano*). The sample *maduro* comprised ripe plantains eight to 10 inches in length. The flesh was pale-yellow and firm but rather moist for plantains. These fruits could be eaten raw and probably are to some extent. The sample of *plátano* consisted of 12 mature fruits. Subsamples were made by quartering the whole, peeled fruits.

Plátano. See *Maduro.*

OTHER:

Cojombro. This plant is possibly native to Brazil, although it is distributed widely but sparsely in tropical America. The fruits are insipid and the plant is grown more as an ornamental than as a source of food. It is seen rarely in Nicaragua. When eaten it is used in soup or as a green vegetable. Five fruits about ten by 20 cm. were purchased for the sample. These were green with yellowish-white, soft, moist flesh. Pulp and seeds were used in the subsamples.

Coyolito. This is a native palm ranging from Nicaragua to Venezuela. It is probably not in cultivation or at least only accidentally. The fruit, which is the part eaten, has little flavor and is not a choice food. It is used mainly for drinks or in preserves. The sample consisted of mature fruits taken from one tree. They were red-to-purple in color. The skin was very tough and there was only a small amount of pulp around a very large seed.

Guayaba (III, *Guayaba*). Twenty-four small, ripe guavas made up the sample. Whole fruits were used in the preparation of the subsamples.

Mamón (IV, *Mamón*). The fruits of the sample were small, three to four cm. in diameter, and the flesh was rather acid. Flesh and seeds were included in the subsamples.

Mimbro. The bilimbi is native to the Malayan region, where it is cultivated to some extent. The fruits are acid and generally are cooked. The plant is sparingly distributed and cultivated elsewhere in the tropics, but has been seen only once in Central America in the course of collecting samples for this study.

Níspero (I, *Níspero*). The sapodilla is believed to be indigenous from Mexico to Costa Rica and is cultivated in northern South America, the West Indies, Florida, and the paleotropics. The sample comprised five typical mature, ripe fruits. The flesh was brownish and moist. Flesh only was used in the subsamples.

Piña (I, *Piña*). Pineapples are native to America, possibly in some of the drier regions of Brazil. Four fruits were purchased for the sample. These were of the whitefleshed variety. In ripe fruits the flesh is firm but not of very good flavor.

Sandía. Watermelons are native to tropical Africa and cultivation is supposed to go back some 4,000 years. They are said to be exceedingly abundant in some parts and generously used, both by the native peoples and animals. In Central America they are cultivated almost exclusively in the dry season and principally in the lowlands along the margins and on the bars of rivers. In general, the fruits are of inferior quality and flavor. The sample consisted of three typical fruits of seven to eight pounds each, taken from the vines. Flesh only was used in the subsample.

Zapote (I, *Zapote*). Five average-sized, ripe fruits made up the sample. Flesh only was taken for the subsamples.

Zapote amarillo (IV, *Zapotillo*). Twenty-six small ripe fruits, taken from trees, made up the sample. These were orange-yellow in color and the flesh was rather dry. The subsamples were prepared from the flesh only.

DRY SAMPLES:

Arroz (III, *Arroz*). In Nicaragua rice is the mainstay of the diet. It is eaten boiled or mixed with other foods, especially with beans, to the extent that "rice and beans" are almost one word. The sample was dry, hulled rice.

Frijol (I, *Habichuela*). The kidney bean is of tropical American origin although it has not been found as an undoubted wild plant. In Nicaragua the red bean is perhaps preferred, but tan and brown beans are not uncommon. The sample *frijol* was an admixture of *frijol bayo* and *frijol rojo* and did not have a distinct name. Sample (a) of *frijol bayo* is a variety common in Nicaragua but not seen as commonly elsewhere. Sample (b) of *frijol bayo* is a variety preferred around Matagalpa. The beans of Sample (c) of *frijol bayo* were dark-tan in color. Varieties represented by the samples of *frijol blanco* and *frijol dulce* are the ones most commonly used with pork or in other mixtures of food. *Frijol dulce* is not common in Central America although there was a good supply in the Managua market where the sample was purchased. *Frijol rojo* is the common type of red bean so abundantly used in Central America.

Maíz (I, *Jilote*). The kernels of Sample (a) of shelled corn were cream-colored, those of Sample (b) were red or purplish in color. Both varieties are used for tamales and tortillas, but the variety represented by Sample (b) is used more commonly in Nicaragua for tamales. Workmen seem to use tamales in preference to tortillas. Preparation is simple: the corn is ground and the *masa* rolled in a banana leaf and cooked.

MISCELLANEOUS:

Cacao. Cacao is native to tropical America and was cultivated in almost all parts of the warm tropics at the time of discovery. It was perhaps the most important and most highly esteemed tree known to the pre-Columbian inhabitants of Central America and Mexico. In addition to use of the seed as food it served as a medium of exchange, a custom that persisted even after The Discovery, since it is mentioned many times by various writers as still in use, the latest date probably being about 1850, when it was mentioned as taking the place of small copper coins in Yucatan. The sample consisted of unroasted seeds purchased in the market. These would not be used as food in this form but would be roasted and ground.

Canarium ovatum Engler. The pili nut is native to the Philippine Islands, where the tree is said to be common in much of the forest area. It is occasionally planted in other areas, for its very fine nuts. In Central America it is grown only in Panama and Honduras, as far as is known. The sample was supplied by the Research Department of the Tela Railroad Company which received it from the Chiriqui Land Company, where it is cultivated under the name *Canarium moluccanum* Blume. The name used in this report is thought to be more nearly correct.

RESULTS AND DISCUSSION

At the time samples were collected in Nicaragua it was not possible to make as complete a survey of edible plants as had been made in Honduras, Guatemala, and El Salvador. Certain difficulties, also, were encountered in preparing and bottling the subsamples, due to the uniformly high temperatures that prevailed during the period when work was being done. There are no particularly unusual foods among the ones collected and only a few of these show values peculiarly different from values shown for samples of the same foods obtained elsewhere. The only new foods not represented in previous reports are *coyolito*, *mimbro*, and *cacao* from Nicaragua, and the pili nut from Panama.

Ayote and *pipi'n*. The two samples of *Cucurbita Pepo* are of interest because of the difference in calcium content. While the content is small in either case (9.8 and 21.5 mg., respectively) and the difference not large (11.7 mg.), it is significant. The *ayote* was a hard-shelled variety of the fruit, and flesh only was included in the sample. The *pipi'n* was a summer squash and the sample included seeds as well as flesh.

Chile dulce. The one sample of sweet pepper was high in content of ascorbic acid (147.0 mg.), as have been all samples examined.

Tomate. Values for all constituents were low but very similar to those obtained for other samples.

Elote and *jilote*. These are essentially different foods, since *elote* consisted of kernels only and *jilote* of very young cobs with kernels. The relatively lower over-all nutritive value of *jilote* might serve as a deterrent to the use of corn until the ears are mature or very nearly so.

Naranja. The two samples, one from Nicaragua and one from Panama, gave values for ascorbic acid (56.4 and 55.0 mg.) somewhat higher than those given for this fruit in most tabulated summaries of vitamin values for foods.

Guayaba. The sample was somewhat higher in content of niacin (2.320 mg.) and lower in content of ascorbic acid (64.0 mg.) than some other samples of this fruit examined. The fruits were small and very green.

Zapote. The specimens making up the sample were the smallest fruits of the zapote obtained during the course of this study on foods of Central America. They gave the highest value for iron (2.62 mg.) of any sample of the fruit analyzed, and values for niacin (2.448 mg.) and ascorbic acid (40.0 mg.) considerably higher than the average values for these nutrients from all samples of the fruit examined.

Zapote amarillo. This fruit gave a very high value for niacin (5.250 mg.) and carotene (2.630 mg.), and contained important amounts of ascorbic acid (59.5 mg.).

Frijol. Seven samples of beans were analyzed, one gray with dark markings, one reddish-tan, one tan, one brown, two white, and one red. All were high in nitrogen (3.125 to 4.095 gm.), calcium (79.3 to 136.3 mg.), iron (7.15 to 8.83 mg.), thiamine (0.090 to 0.383 mg.), riboflavin (0.103 to 0.178 mg.), and niacin (1.831 to 2.893 mg.). The higher values for nitrogen (3.915 and 4.095 mg.), iron (8.22 and 8.83 mg.), thiamine (0.377 and 0.383 mg.), and niacin (2.380 and 2.893 mg.) are shown by *frijol blanco* and *frijol dulce*, respectively. These are both small white beans, *frijol dulce* being the smaller of the two.

SUMMARY

Values are presented for content of moisture, ether extract, crude fiber, nitrogen, ash, calcium, phosphorus, iron, carotene, thiamine, riboflavin, niacin, and ascorbic acid obtained in analyses of 51 samples of edible plants collected in Nicaragua in November, 1946, and three samples of fruits, and one of a nut, collected in Panama.

Four of the foods listed are not represented in previous reports of this series.

Several of the fruits gave relatively high values for some nutrients. These are discussed.

Attention is called to the two samples of legumes with high values for four nutrients.

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FACTORS INFLUENCING QUALITY OF TOMATO PASTE. I. CHEMICAL COMPOSITION OF CALIFORNIA COMMERCIAL TOMATO PASTE

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Although a large amount of work has been reported on the chemistry and technology of tomato products, only a small portion has been devoted to tomato paste. Consequently, experiments are under way in this laboratory on the influence of various processing factors on this product.

To obtain background information on commercial processing, and to determine the degree of uniformity among commercial pastes, 12 plants were visited during the 1946 season, 10 in central, and two in southern, California. Although minor variations were many, the following general procedure was used in preparing the paste: (1) Whole, ripe tomatoes were washed and transferred to moving belts for sorting and trimming; (2) the tomatoes were then passed through a coarse disintegrator and the ground tomatoes heated to temperatures ranging from 71 to 88°C. (160 to 190°F.); (3) the hot mass was then screened to remove the skins, seeds, and coarse pulp; (4) the screened juice was concentrated in vacuum pans to from 25 to 30 per cent total solids at about 25 inches of vacuum; (5) the paste was then heated to from 82 to 93°C. (180 to 200°F.) and filled into cans; (6) the filled cans were or were not heat processed and cooled by air or water.

The effects of some variations of processing on quality of product have been indirectly studied in work on the chemistry of tomatoes and their processing relative to use as fresh fruit, canned whole fruit, and juice. Work on the composition of tomatoes as affected by variety, environment, and cultural practices, shows large variations in total solids, minerals, vitamin C, and color content which would directly influence the composition of any processed product. Lamb, Pressley, and Zuch (1947), Sale (1946), and Strachan and Atkinson (1946) have studied the retention of vitamin C in the making and storage of tomato juice. Mitchell (1935) and Poe, Wyss, and McEver (1934) have made surveys of commercial tomato juice which also show great variation of composition. Studies already made upon the coloring matter of tomatoes and tomato juice are valuable in relatin to any work on the color of tomato paste. The Munsell method of evaluating color has been applied to tomato products by MacGillivray (1931), and Emanuelle and Mauri (1932) have reported on a similar method. However, data on the effect on the quality of paste of such factors as hot-break temperatures, temperature and pressure of concentration, metallic contamination, or type of filled-can cooling, are not available in the literature.

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As the quality of tomato paste is usually governed by its flavor, consistency, and color, means of measuring these characteristics must be available. Therefore, as a part of this preliminary work, analyses of the commercial product of the various plants visited were made to determine: (1) the variation in composition of commercial tomato paste, (2) constituents that might be used to evaluate quality, and (3) the analytical procedures to be used for the various constituents. Seventeen samples of paste were obtained from the 12 plants visited. These samples were analyzed for total solids, insoluble solids, pH, ash, copper, iron, total acidity, salt, total sugars, vitamin C, consistency, color index, lycopene, and carotene. The composition of these pastes and the analytical methods used are reported here, along with observations on the effect of processing variations on composition.

ANALYTICAL METHODS

Where a specific method was already available for determining a constituent in tomato products, it was used as such, without further investigation beyond a determination of precision. With other methods, tests were run to ascertain their adaptability to tomato paste. The precision of the analytical methods used for the constituents of tomato paste reported in this paper are listed (Table 1).

TABLE 1

Precision of Analytical Methods

Determination	Standard deviation (for six aliquots)
Total solids:	
Vacuum oven	0.1 pct.
Refractometer	0.2 pct.
pH	0.01 pct.
Consistency	2
Insoluble solids	0.12 pct.
Ash	0.04 pct.
Copper	1 p.p.m. in 10
Iron	0.5 p.p.m. in 10
Acidity	0.03 pct.
Salt	0.02 pct.
Sugar	0.3 pct.
Vitamin C	0.7 mg.

A. *Total Solids:* The total-solids contents of the pastes were determined by the methods described by Bigelow, Smith, and Greenleaf (1941).

B. *Insoluble Solids:* The tentative method according to the A.O.A.C. (1945) for the determination of insoluble solids in fruit pulp was adapted to tomato paste as follows: Twenty gm. of paste were added to one liter of hot distilled water in a two-liter beaker, with vigorous stirring. The mixture was then filtered through a large, weighed filter paper (24 cm. S&S No. 595) on a Büchner funnel with suction. The residue was washed with two liters of hot water and the filter paper and residue dried at 100°C. (212°F.) for two hours. The dried material was then cooled in a desiccator, weighed, and the percentage of insoluble solids calculated from the weight of the residue.

C. *Acidity—Salt—Sugar:* These three determinations were made on the same aliquot of paste.

1. *Preparation of a Stock Extract:* A 25-gm. sample of paste was mixed with 300 ml. of hot water, the mixture allowed to stand for five minutes, and 10 gm. of filter-aid added. It was then filtered with suction. The residue on the filter was washed with 100 ml. of hot water. The total filtrate was then transferred to a 500-ml. volumetric flask, cooled, and made to volume.

2. *Acidity:* Acidity was determined on an aliquot of the stock extract according to the procedure by Bigelow *et al.* (1941).

3. *Salt:* The amount of salt in the paste was determined by the second procedure for salt listed by Bigelow *et al.* (1941).

4. *Total Reducing Sugars:* The invert sugar after acid hydrolysis was determined in an aliquot of the stock extract by the Lane-Eynon method according to the A.O.A.C. (1945).

D. *Vitamin C:* The ascorbic acid content of the paste was determined by a modification of the dye method listed by the A.O.A.C. (1945) for fruit products. To 25 gm. of the paste were added 100 ml. of the phosphoric-acetic solution, and the mixture agitated. After 10 minutes, five gm. of Hyflo-Supercel were added and the mixture filtered with suction. The filtrate was transferred to a 250-ml. volumetric flask, made to volume, and thoroughly mixed. Five ml. of the standard dye solution (one ml. equivalent to about 0.1 mg. of ascorbic acid) were measured from a 10-ml. burette into a 50-ml. Erlenmeyer flask and titrated to the colorless endpoint with the filtrate from the paste. This reverse titration produces a clearer endpoint than the usual direct titration with the dye. The mg. of ascorbic acid per 100 gm. of paste were calculated from the amount of unknown solution used.

E. *pH:* The pH of the paste was measured directly with a glass-electrode pH meter.

F. *Ash:* The ash contents of the pastes were determined by a method for sugar products listed by A.O.A.C. (1945), except that the temperature of ashing was accurately held at 500°C.(932°F.).

G. *Copper and Iron:* These metals were determined by an unpublished spectrophotometric method used at the Eastern Regional Research Laboratory of the U. S. Department of Agriculture for measuring these elements in crude rubber. The reactions of copper with sodium diethyldithiocarbamate and iron with *o*-phenanthroline were used as the basis of analysis. The method gave results with tomato paste which checked closely with those obtained by a spectrographic method used at the Western Regional Research Laboratory of the U. S. Department of Agriculture.

H. *Consistency:* The consistencies of the pastes were determined with the Penetrometer made by Precision Scientific Company,[2] according to a procedure developed by Underwood and Keller (1948). The instrument

[2] Mention of special equipment or materials throughout this paper does not imply they are endorsed or recommended by the Department of Agriculture over others of a similar nature not mentioned.

measures in 1/10th mm. the depth of penetration of a plastic cone weighing 15 gm. into a constant volume of sample (300 ml.), by a force of 25 gm. acting for five seconds at a temperature of 25°C. (77°F.).

I. *Color Index and Carotenes:* The color index and carotenes were measured by methods described by Davis (1949).

DISCUSSION OF RESULTS

Results of the determinations are recorded (Tables 2 and 3). All values are averages of duplicate analyses, and abnormal values were further checked to insure accuracy. Generally, the data demonstrate that commercial tomato paste may vary considerably in chemical composition and

TABLE 2

Chemical Analysis of California Tomato Pastes[1]

Sample No.	Tomato variety	Total solids		pH	Consistency [2]	Color index [3]
		Vacuum oven	Refractometer			
		pct.	pct.			
A	Pearson	24.1	24.4	4.15	332	155
B	Pearson	27.3	27.3	4.19	278	205
C	Pearson	26.0	28.0	4.22	340	160
D	Pearson	28.5	29.9	4.21	296	192
E	Pearson	24.8	24.5	4.22	312	175
F_1	Pearson	27.8	28.6	4.12	301	169
F_2	Pearson and San Marzano	24.8	25.8	4.19	324	179
F_3	San Marzano	27.7	29.0	4.23	302	172
G	Pearson	26.2	26.4	4.20	336	175
H	Pearson	25.4	27.3	4.19	295	173
J_1	Santa Clara	31.0	32.1	4.22	268	186
J_2	Santa Clara	31.6	32.7	4.24	262	172
K_1	Santa Clara and Pearson	26.4	28.0	4.24	267	160
K_2	Santa Clara and Pearson	24.9	25.9	4.25	266	154
L	½ Round and ½ San Marzano	27.4	28.4	4.25	219	164
M_1	4 Round and 1 San Marzano	23.6	24.7	4.30	313	166
M_2	Winter Pennheart	24.7	24.4	4.10	310	101

[1] Based on paste as received.
[2] Consistency is expressed as 1/10th mm. penetration of a standard cone.
[3] Color index is expressed as scale readings of Klett Colorimeter.

physical properties. As it was impossible to obtain samples of raw tomatoes for control data, no conclusions can be drawn concerning causes of the variations, especially the effect of processing variations. The main cause is probably the differences in composition of the raw tomatoes, for, as already stated, tomatoes have been found to vary significantly in chemical composition due to variety, environmental conditions, age, and treatment after harvesting. However, some facts of interest can be stated from the results (Table 2 and 3).

Total Solids: The statements of industrial personnel concerning determination of total solids are substantiated by this study. Fourteen of the 17 samples tested were an average of 1.1 per cent higher in total solids by the refractometer method than by the vacuum-oven method. The refractometer method is an empirical one, developed as a rapid plant-control test, based on total solids by the vacuum-oven method as related to refrac-

TABLE 3

Chemical Analysis of Commercial California Tomato Pastes[1]

Sample No.	Tomato variety	Insol. sol.	Ash 500°C.	Copper	Iron	Acidity	Salt	Sugar	Vit. C.	Lycopene	Carotene
		pct.	*pct.*	*p.p.m.*	*p.p.m.*	*pct.*	*pct.*	*pct.*	*mg./100 gm.*	*p.p.m.*	*p.p.m.*
A	Pearson	2.48	2.28	7	81	1.33	0.83	12.0	69	574	31
B	Pearson	2.76	1.98	6	25	1.43	0.36	12.5	50	595	22
C	Pearson	2.50	2.08	12	104	1.62	0.31	14.0	73	544	38
D	Pearson	2.05	2.04	10	13	1.36	0.38	14.2	83	600	36
E	Pearson	2.54	2.04	6	26	1.34	0.38	12.5	56	528	26
F_1	Pearson	2.59	2.07	12	22	1.58	0.33	12.5	64	503	32
F_2	Pearson and San Marzano	2.92	2.05	24	48	1.41	0.35	12.7	72	466	28
F_3	San Marzano	2.44	2.06	23	30	1.39	0.36	11.9	74	565	37
G	Pearson	2.14	1.87	6	20	1.37	0.25	13.0	67	646	28
H	Pearson	2.23	1.97	6	18	1.46	0.41	13.4	49	604	36
J_1	Santa Clara	2.39	1.88	5	38	1.28	0.29	12.4	57	455	34
J_2	Santa Clara	2.28	1.90	6	30	1.26	0.28	13.0	59	546	32
K_1	Santa Clara and Pearson	2.61	1.99	13	32	1.23	0.30	12.8	59	523	32
K_2	Santa Clara and Pearson	3.10	1.87	10	56	1.28	0.30	13.1	55	412	24
L	½ Round and ½ San Marzano	2.98	1.99	14	44	1.14	0.37	11.8	63	584	32
M_1	4 Round and 1 San Marzano	2.75	2.11	18	58	1.43	0.30	11.7	66	596	28
M_2	Winter Pennheart	3.52	2.04	32	16	1.40	0.34	13.4	44	306	22

[1] Based on 25 per cent total solids content of paste.

tometer readings on liquid from the paste. The differences in values by the two methods indicate a lack of homogeneity in the composition of tomato juices. This may well be true, as eastern varieties of tomatoes were used to determine the relationship of the refractive index of the serum and the total solids of the paste for the tables now in use with the refractometer method. The authors of the method, Bigelow *et al.* (1941), have fully discussed the limitations of use of the refractometer procedure, and the method should be used with full knowledge of them. An interesting subject for study would be the relationship of the refractive index of the serum and the total solids content of commercial varieties of tomatoes grown in California at the present time.

Consistency: The consistency of the pastes varied widely at the same total-solids content. Work has been started to investigate the causes of the variation and possible means of control.

Iron and Copper Content: These metals were found to vary by the largest amount of all the constituents determined. Again, no conclusions can be made regarding the factors influencing their concentration in the paste and their effect on vitamin C, color, and other components. Samples J_1 and J_2 are from the same day's run from the same processing plant, J_1 from a stainless steel evaporator, and J_2 from a copper evaporator. J_1 was was found to contain five p.p.m. of copper and 59 mg./100 gm. of vitamin C, while J_2 contained six p.p.m. of copper and 59 mg./100 gm. of vitamin C. Also, Samples K_1 and K_2 were obtained from the same plant from the same batch of paste, K_1 from a brass can-filler, and K_2 from a stainless-steel filler. Again, the differences in copper and vitamin C content are not significant. This agrees with the work of Kotlyar, Oikhman, and Shnaidman (1935) and Lamb and Lloyd (1939), who have reported that after the oxide film on copper has been removed, the metallic copper remaining is not very soluble. Further proof was obtained from some samples of paste from a plant at the start of a run after several days' shutdown. This paste at the beginning of the first day's run contained 108 p.p.m. copper; at the end of the first day, 49 p.p.m., and at the end of the second day, 32 p.p.m. The effect of metals on color and vitamin C will be studied in further work, as well as factors affecting contamination.

Vitamin C: The ascorbic acid content of the pastes varied from 44 to 83 mg./100 gm. paste, at 25 per cent total-solids.

CONCLUSIONS

Results presented in this paper illustrate the variation in composition of California commercial tomato paste. As a preliminary background for future work, the following information has been obtained:

1. The characteristics of the paste—color, consistency, and vitamin C content—show enough variation to be used in evaluating quality of paste.

2. Analytical methods for determining total solids, pH, consistency, insoluble solids, ash, copper, iron, acidity, salt, sugar, and vitamin C have been tested and adapted for tomato paste in preparation for their use in future work.

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REDUCED ASCORBIC ACID CONTENT OF FOODS SERVED IN INSTITUTIONAL QUANTITIES

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The ascorbic acid content of foods served at two Oregon State College dining halls was determined in connection with ascorbic acid metabolism studies with groups of freshman students at the college.[2] Two of the studies were of four weeks' duration, while the other two lasted 30 days each. The two groups of girls were fed at a dining-room of a girls' dormitory feeding about 175 students. The boys' groups were fed at the cafeteria of the Memorial Union, where about 700 students are fed.

For the purposes of the metabolism studies, the subjects were limited in the quantity of ascorbic acid-rich foods they could have during part of the study. Therefore, the number of times each food was served and analyzed refers to the times they were served to our subjects, and not necessarily the frequency of their appearance on the dormitory menus. For example, the food records show that peaches were served more frequently, and that oranges and grapefruit appeared fewer times for our subjects than on the regular dormitory menu.

EXPERIMENTAL PROCEDURE

The reduced ascorbic acid content of the food was determined by the method of Loeffler and Ponting (1942). Any food which was known, or thought, to contain ascorbic acid was analyzed each time it was served. Milk was an exception; since it was delivered once a day to the dining halls, it was analyzed each morning after breakfast.

Solid foods were sampled at the dining halls at the time food for the subjects was weighed. Twenty-five-gm. portions of foods known to contain relatively large amounts of ascorbic acid (e.g., orange sections, tomato, cabbage, and grapefruit) and 50-gm. portions of food containing smaller amounts of ascorbic acid, were weighed directly into one-half-pint Mason jars. A 100-ml. portion of one per cent HPO_3 was added from a graduated cylinder. The samples were taken immediately to the laboratory, where each sample was transferred to a Waring Blendor with 250 ml. of one per cent HPO_3. Thus, each sample of 50 gm. was extracted with a total

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[2] A summary of the data on these studies may be found in Technical Bulletins 17 (1949), and 18 (1950), Oregon Agricultural Experiment Station, Corvallis, Oregon.

of 350 ml. of one per cent HPO_3. When smaller samples were used the proportion of metaphosphoric acid to sample was at least seven to one, also. Liquids to be analyzed were placed in one-half-pint Mason jars and taken to the laboratory before addition of the HPO_3. Throughout these studies, all foods were analyzed for ascorbic acid immediately after each meal.

DISCUSSION OF RESULTS

Results of the food analyses are presented (Table 1),[3] including data showing number of times each food was served, the mean ascorbic acid content in mg. per 100 gm. of food, standard deviation, and range.

Some of the foods analyzed which proved to be outstanding sources of ascorbic acid were the citrus fruits, tomatoes, sweet potatoes, and vegetables of the cabbage family. Although Irish potatoes did not contain as much ascorbic acid per 100 gm. as did the above mentioned foods, potatoes may be considered a significant source of ascorbic acid because of the quantities in which they are eaten and the frequency with which they are served. Other significant sources which should not be overlooked are bananas, canned pineapple, and canned asparagus. Catsup contains an appreciable amount of ascorbic acid, but since it is not one of the main foods in our diet its contribution to the ascorbic acid intake is rather small. Desserts as a group added very little ascorbic acid to the diet, except when they were made with fruits.

The variability in results of analyses of such foods as broccoli, cooked cabbage, boiled potatoes, peas, squash, and tomatoes might be explained by one or more such factors as variability in fresh material, storage, sampling, and cooking, which affect the concentration of ascorbic acid in foods.

The apparent ascorbic acid content of liver and potato chips was fairly high. Since it was felt that interfering reducing substances accounted at least in part for these high values, these two foods were omitted from the diet for the remainder of the studies.

SUMMARY

Data are presented for the reduced ascorbic acid content of foods served at two Oregon State College dining halls. The samples were analyzed immediately following each meal by the method of Loeffler and Ponting (1942).

REFERENCE

LOEFFLER, H. J., AND PONTING, J. D., 1942. Ascorbic acid. Rapid determination in fresh, frozen, or dehydrated fruits and vegetables. Ind. Eng. Chem., Anal. Ed. 14, 846-849.

[3] More detailed results may be found in the Technical Bulletins referred to in footnote 2.

TABLE 1

Ascorbic Acid Content of Foods Served In Institutional Quantities

Food	Total times served	Mean ascorbic acid content	Standard deviation	Range
		mg./100 gm.		*mg./100 gm.*
1. Fruits:				
Apple, baked	6	0.2	0.3	0.0-0.6
Apple juice	13	0.3	0.4	0.0-1.1
Apple, raw	9	3.5	1.7	1.6-6.4
Apple sauce	8	0.1	0.2	0.0-0.5
Apricots, canned	22	3.4	1.7	0.0-6.9
Apricot juice	13	3.5	1.9	0.6-6.9
Apricots, dried, stewed	1	3.3	....	.....
Apricot juice, dried, stewed	1	3.3	....	.....
Apricot nectar	1	1.6	....	.....
Avocado	1	2.4	....	.....
Banana	8	7.7	3.6	0.0-12.4
Cherries, red canned	1	0.0	....	.....
Cherries, Royal Anne	4	2.6	1.6	0.4-3.8
Cherries, Royal Anne, juice	3	2.4	1.9	0.4-4.3
Dates	1	0.0	....	.....
Fruit cup	9	2.7	0.9	1.7-4.3
Fruit cup, juice	4	4.6	3.5	1.7-9.6
Fruit jello	2	2.0	2.8	0.0-3.9
Fruit juice mixture	7	19.2	7.3	9.7-29.4
Grapefruit, fresh	9	39.6	11.7	20.2-50.8
Grapefruit juice, fresh	3	29.7	5.6	25.5-36.1
Grape juice	11	0.0	0.1	0.0-0.3
Grape and apricot juice	2	0.4	0.6	0.0-0.9
Orange, fresh	11	62.9	11.6	47.2-89.0
Orange juice, canned	1	20.5	....	.....
Orange juice, fresh	3	40.1	7.2	33.7-48.0
Orange and grapefruit juice	1	22.1	....	.....
Peaches, canned	43	3.9	1.1	1.6-5.8
Peaches, canned, juice	19	3.6	2.7	2.2-5.4
Peaches, frozen	1	3.0	....	.....
Pears, canned	26	1.0	2.4	0.0-2.8
Pears, canned, juice	6	1.1	0.3	0.7-1.6
Pears, fresh	2	2.2	1.1	1.4-2.9
Pineapple, canned	20	6.2	1.2	4.7-8.3
Prunes, canned	13	1.8	1.6	0.0-5.4
Prunes, canned, juice	12	1.2	0.6	0.1-2.0
Prunes, dried, stewed	17	2.0	1.1	0.0-3.7
Prunes, dried, stewed, juice	8	0.8	0.9	0.0-2.5
Raisins and nuts	1	0.0	....	.....
2. Vegetables:				
Asparagus, canned	2	14.8	2.5	13.0-16.6
Beans, kidney, canned	2	2.4	2.2	0.9-3.9
Beans, string, canned	38	0.3	0.5	0.0-2.0
Beets, canned	29	1.7	1.7	0.0-5.5
Beets, pickled	1	0.7	....	.....
Broccoli	2	28.2	37.2	1.9-54.5
Cabbage, cooked	4	22.0	7.7	11.2-28.2
Cabbage, raw	1	70.8	....	.....
Carrots, canned	1	0.0	....	.....
Carrots, cooked	22	1.1	1.3	0.0-3.7
Carrots, raw	21	3.3	1.9	0.2-7.5
Carrots and peas	4	0.8	0.9	0.0-1.6
Cauliflower	3	48.0	12.5	36.6-61.4
Celery, cooked	1	1.0	....	.....

TABLE 1 *(Continued)*

Ascorbic Acid Content of Foods Served In Institutional Quantities

Food	Total times served	Mean ascorbic acid content	Standard deviation	Range
		mg./100 gm.		*mg./100 gm.*
Celery, raw	28	7.1	3.0	2.6-15.7
Corn, canned	28	2.7	2.0	0.0-6.7
Corn pudding	1	2.1	....	.....
Lettuce	98	1.4	1.3	0.0-5.5
Peas, canned	34	3.6	2.5	0.0-7.6
Peas, frozen	11	3.8	3.0	0.0-9.8
Potatoes, baked	3	9.4	2.0	7.3-11.4
Potatoes, boiled	8	6.5	2.8	1.8-11.1
Potatoes, browned	2	4.8	0.8	4.2-5.4
Potatoes, creamed	5	2.5	2.2	0.2-4.9
Potatoes, escalloped	2	2.8	0.7	2.3-3.3
Potatoes, fried	2	1.9	2.7	0.0-3.8
Potatoes, mashed	44	2.6	3.4	0.0-12.9
Potato patties	2	0.3	0.4	0.0-0.5
Potatoes, steamed	10	6.0	3.9	0.0-13.0
Potatoes, sweet	6	19.4	8.0	10.3-33.0
Radishes	1	22.5	....	.....
Spinach, canned	7	1.7	1.9	0.9-2.5
Spinach, fresh	2	10.3	1.9	8.9-11.6
Squash	6	4.5	5.3	0.0-12.5
Succotash	1	0.0	....	.....
Tomato, fresh	10	15.5	5.8	9.6-26.6
Tomato juice	3	24.8	4.2	19.9-27.8
Tomatoes, canned	3	16.5	7.6	7.7-21.0
Vegetables, mixed	4	1.1	1.2	0.0-2.5
3. Meat mixtures and substitutes:				
Beans, baked	5	1.6	2.0	0.0-4.6
Beans, Navy, with tomato sauce	2	1.2	1.7	0.0-2.4
Beef hash	4	0.0	0.0	.....
Beef with noodles	2	0.0	0.0	.....
Beef stew	9	2.3	2.8	0.0-7.5
Bread dressing	5	0.0	0.0	.....
Chili	2	0.5	0.7	0.0-1.0
Eggs, scrambled	3	0.3	0.6	0.0-1.0
Ham, peas, and corn	1	0.0	....	.....
Kidney beans with bacon	1	0.7	....	.....
Liver, fried	1	25.7	....	.....
Meat with corn	1	0.0	....	.....
Meat loaf with tomato	3	2.0	1.7	1.0-4.0
Meat pie	1	0.0	....	.....
Meat salad	2	0.6	0.8	0.0-1.1
Meat spread	1	0.0	....	.....
Rice and tomatoes	1	1.4	....	.....
Salmon loaf with lemon	3	0.0	0.0	.....
Spaghetti	3	0.4	0.7	0.0-1.2
Spaghetti with tomato	1	5.1	....	.....
4. Dairy products:				
Cheese, cottage	12	0.0	0.1	0.0-0.3
Chocolate, hot	1	0.0	....	.....
Cocoa	3	0.0	0.0	.....
Cream	45	0.0	0.1	0.0-0.6
Cream, whipped	17	0.1	0.2	0.0-0.6
Milk	117	0.2	0.3	0.0-1.3

TABLE 1 *(Continued)*

Ascorbic Acid Content of Foods Served In Institutional Quantities

Food	Total times served	Mean ascorbic acid content	Standard deviation	Range
		mg./100 gm.		*mg./100 gm.*
5. Desserts:				
Apple crisp	1	0.0	....	.....
Cake with orange glaze	1	3.6	....	.....
Cherry cobbler	2	0.0	0.0	.....
Cherry roll	1	0.0	....	.....
Custard, baked	1	0.0	....	.....
Custard, pumpkin	1	0.0	....	.....
Date Torte	1	0.0	....	.....
Ice cream:				
Apricot	1	0.0	....	.....
Berry	1	0.4	....	.....
Butterscotch ribbon	1	0.0	....	.....
Caramel ribbon	1	0.0	....	.....
Chocolate	6	0.2	0.3	0.0-0.7
Chocolate ribbon	10	0.0	0.1	0.0-0.3
Peppermint	1	0.5	....	.....
Raspberry ripple	4	0.1	0.1	0.0-0.3
Strawberry	1	0.1	....	.....
Vanilla	21	0.2	0.3	0.0-1.0
Jello with apricots	1	1.7	....	.....
Jello with bananas	1	1.6	....	.....
Jello with blackberries	1	2.3	....	.....
Jello with mixed fruit	3	2.2	2.0	0.0-3.7
Jello with oranges	1	12.2	....	.....
Jello with peach and pear	1	1.7	....	.....
Jello with peaches	1	1.6	....	.....
Jello with pears	2	1.3	0.1	1.2-1.4
Jello with pineapple	3	2.6	0.7	2.2-3.4
Jello with strawberry and pineapple	1	2.3	....	.....
Peach crisp	1	2.0	....	.....
Peach cobbler	1	0.0	....	.....
Pie filling				
Apple	6	0.2	0.4	0.0-1.0
Apricot	1	2.5	....	.....
Banana cream	1	0.0	....	.....
Cherry	1	0.0	....	.....
Mince	1	0.9	....	.....
Peach	1	2.3	....	.....
Pumpkin	2	0.1	0.1	0.0-0.2
Pudding				
Banana	1	0.0	....	.....
Banana butterscotch	1	0.0	....	.....
Blanc mange	3	0.6	1.0	0.0-1.7
Butterscotch	1	0.0	....	.....
Chocolate	4	0.7	1.1	0.0-2.3
Rice, with raisins	1	0.0	....	.....
Pineapple upsidedown cake	2	0.7	0.9	0.0-1.3
Washington cream pie	2	0.0	0.0	.....
6. Soups:				
Clam chowder	2	1.4	0.2	1.2-1.6
Split pea	1	1.5	....	.....
Split pea with ham	2	0.8	0.8	0.3-1.4
Turkey noodle	2	0.0	0.0	.....
Vegetable	9	1.5	1.7	0.0-5.1
7. Salads:				
Apple	12	2.8	1.3	0.5-5.1

TABLE 1 *(Concluded)*

Ascorbic Acid Content of Foods Served In Institutional Quantities

Food	Total times served	Mean ascorbic acid content	Standard deviation	Range
		mg./100 gm.		*mg./100 gm.*
Cabbage slaw	3	40.7	11.9	32.9-54.4
Carrot and celery	1	2.4	....	.....
Carrot and date	1	0.0	....	.....
Carrot and raisin	2	0.9	0.5	0.5-1.2
Carrot, string bean, and asparagus	1	1.0	....	.....
Fruit, mixed	2	2.6	1.1	1.8-3.3
Gelatin with cottage cheese	1	0.0	....	.....
Gelatin with mixed fruit	1	1.4	....	.....
Gelatin with pineapple	1	3.0	....	.....
Gelatin with pineapple and carrot	1	0.0	....	.....
Gelatin with vegetable	2	1.3	0.1	1.2-1.3
Halibut, egg, and celery	1	1.7	....	.....
Ham	1	0.0	....	.....
Macaroni	2	0.6	0.6	0.2-1.0
Potato	3	1.9	3.3	0.0-5.7
Turkey	2	1.1	0.5	0.8-1.5
Vegetable with chicken	1	0.9	....	.....
Vegetable, mixed	22	11.5	12.6	0.0-37.6
Waldorf	1	1.6	....	.....
8. Pickles, relishes, dressings:				
Catsup	5	19.7	4.4	14.9-25.6
French dressing	5	0.2	0.3	0.0-0.8
Maple syrup	1	0.0	....	.....
Mayonnaise with parsley	1	0.0	....	.....
Mustard	2	3.0	0.7	2.4-3.5
Mustard with horseradish	1	4.3	....	.....
Olives, stuffed	3	0.0	0.0	.....
Potato chips	2	28.3	5.9	24.1-32.4
Pickles, sweet	6	0.0	0.1	0.0-0.3
Salad dressing	9	1.5	1.6	0.0-4.2
Tartar sauce	2	0.2	0.3	0.0-0.4
Tomato sauce	2	13.3	5.0	9.8-16.8
Toppings (for ice cream, cakes, etc.)				
Apricot	2	2.4	0.5	2.1-2.8
Cherry	1	1.5	....	.....
Chocolate	1	3.4	....	.....
Marshmallow	2	0.0	0.0	.....
Marshmallow with apple	1	0.6	....	.....
White sauce	1	0.0	....	.....
9. Jams and spreads:				
Jam				
Apricot	10	0.5	0.3	0.0-1.0
Apricot with pineapple	16	0.5	0.6	0.0-2.3
Berry	18	2.2	1.5	0.4-6.1
Berry and apple	1	0.0	....	.....
Grape	5	0.8	0.5	0.0-1.2
Loganberry	1	2.2	....	.....
Peach	3	0.3	0.4	0.0-0.7
Peach with apricot	1	0.1	....	.....
Red raspberry	1	6.2	....	.....
Honey	2	0.5	0.7	0.0-1.0
Peach butter	2	1.1	0.7	1.0-1.1
Peanut butter	2	2.3	3.3	0.0-4.6
Peanut butter with apricot jam	1	3.7	....	.....

COMPOSITION OF FOOD PLANTS OF CENTRAL AMERICA. VI. COSTA RICA

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In 1946 a study was begun in these laboratories to obtain information on the composition of edible plants found growing in the several countries of Central America. This report is the sixth in a series in which data from this study are being presented. In the first five papers results are presented as follows: I, 121 samples from Honduras, Munsell, Williams, Guild, Troescher, Nightingale, and Harris (1949); II, 124 samples of vegetables from Guatemala, Munsell, Williams, Guild, Troescher, Nightingale, and Harris (1950a); III, 106 samples, including 60 fruits, from Guatemala, Munsell, Williams, Guild, Troescher, Nightingale, and Harris (1950b); IV, 194 samples collected in El Salvador, Munsell, Williams, Guild, Troescher, Nightingale, Kelley, and Harris (1950c); and V, 51 samples from Nicaragua and four from Panama, Munsell, Williams, Guild, Troescher, and Harris (1950d). The present paper covers data obtained for 154 samples from Costa Rica collected in two periods, March, 1948, and March and April, 1949.

The procedure for collection and shipment of samples has been described, Munsell *et al.* (1949). Three slurries were prepared of all samples except the staple foods. The same 13 constituents were measured as noted in previous reports and no changes were made in methods of analysis beyond those noted in the second report. For each sample there was the usual data sheet and kodachromes of representative specimens, for filing at the Massachusetts Institute of Technology and the Escuela Agrícola Panamericana.

Of the 154 samples, 136 were purchased in markets in San José, 27 in markets of Alajuela, Cartago, or Heredia, and one from a street vendor in San José. The places where samples originated, with information on average altitude, prevailing soil type, and estimated annual rainfall are shown (Table 1). It will be noted that many of the samples came from Cartago and other places around and near San José. The outlying areas represented are few and scattered, and were mostly in the southeast coastal region or the northwest highland area. Ninety foodstuffs are represented in the 154 samples and for 42 of these there were more than one sample.

[1] Description of some of the foods has already been given in earlier reports. This is indicated by a notation in parentheses giving the series number for the reference—I, Munsell *et al.* (1949); II, Munsell *et al.* (1950a); III, Munsell *et al.* (1950b); IV, Munsell *et al.* (1950c); V, Munsell *et al.* (1950d)—and the name of the food under which the description is given.

TABLE 1

Information on Altitude, Prevailing Soil Type, and Approximate Average Annual Rainfall in Areas Where Samples Originated

Town	Department	Altitude	Soil	Estimated annual rainfall	No. of samples
		ft.	*type*	*in.*	
Alajuela	Alajuela	3,000	Volcanic	60	9
Alajuelita	San José	3,500	Volcanic	60	5
Batán	.....	2,000	Volcanic	70	1
Cartago	Cartago	3,900-7,000	Volcanic	70	47
Cote de Cartago	Cartago	5,500	Volcanic	70	1
Coto	Cartago	4,500	Volcanic	.....	1
Coyolar	Alajuela	3,000	Volcanic	70	1
Escassú	San José	3,500	Volcanic	70	1
Grecia	Alajuela	3,500	Volcanic	.....	1
Guápiles	Limón	600-900	Volcanic	100	3
Hatillo	San José	3,500	Volcanic	.....	1
Heredia	Heredia	3,500	Volcanic	60	1
Jiménez	Limón	2,000	Volcanic	100	1
La Sábana de San José	San José	3,400	Volcanic	.....	1
Liberia	Guanacaste	1,000	.....	.....	1
Limón	Limón	0-50	Sand	100	4
Martina de Limón	Limón	0	Alluvial	100	1
Naranjo	Alajuela	3,000	Volcanic	.....	1
Orosi	Cartago	3,300	Volcanic	70	1
Orotina	Alajuela	600-750	Volcanic outwash	60	6
Pacayas	Cartago	4,200	Volcanic	.....	1
Puerto Jiménez	Puntarenas	30	Alluvial	.....	1
Puerto Limón	Limón	300	.....	.....	1
Puntarenas	Puntarenas	100	Sand; alluvial outwash	60	5
Purisenl	San José	3,300	Volcanic	.....	3
San Antonio Belén	Heredia	3,000	Volcanic	60	5
San Antonio de Escassú	San José	3,900	Volcanic	70	1
San Carlos	Alajuela	2,500	Volcanic	.....	1
San Isidro Coronado	San José	4,300	Volcanic	70	2
San Isidro del General	San José	2,100	.....	.....	3
San Juan en el Cantón de San José	San José	4,500	Volcanic	70	1
San Mateo	Alajuela	750	Volcanic	70	1
San Pedro Montes de Oca	San José	3,600-5,000	Volcanic	70	5
San Vicente de Moravia	San José	3,900	Volcanic	.....	3
Santa Ana	San José	3,300	Volcanic	.....	14
Santa Ana de Escassú	San José	3,600	Volcanic	70	2
Santa María Asserrí	San José	4,200	Volcanic	70	1
Santa María de Dota	San José	4,200	.....	.....	1
Siquirres	Limón	200	Volcanic	100	1
Taras	Cartago	4,500	Volcanic	.....	1
Tierra Blanca de Cartago	Cartago	4,800	Volcanic	70	1
Tres Ríos	San José	4,000	Volcanic	.....	1
Turrialba	Cartago	2,000	Volcanic	100	3
Turrúcares	Alajuela	3,000	Volcanic	.....	2
Villa de Colón	San José	3,500	Volcanic	60	1
Volcán Poas, eastern slopes	Alajuela	3,000-5,000	Volcanic	100	2
Zarcero	Alajuela	5,700	Volcanic	80	3

DESCRIPTIONS AND USES OF FOODS STUDIED [1]

EARTH VEGETABLES:

Ajo. Garlic is native to Asia and was widely diffused in earliest times. It is used primarily as flavoring for other foods and in Central America there is scarcely a food, desserts excepted, to which garlic may not be added and often in such amounts as to make the food unpalatable to the uninitiated. The sample consisted of about 50 bulbs having white skins. These were of good quality but were very strong. The subsamples were taken from the mixed cloves after peel was removed.

Camote (I, *Camote*). The sweet potato is apparently of American origin and had been in cultivation in pre-Colombian time long enough for its area of dispersal to include most of tropical and subtropical America. Even so, it does not receive the attention it should as food for both man and animals. Both samples consisted of mature roots with purple skins. The flesh of those of Sample (a) was pale-orange-yellow, while that of the roots of Sample (b) was very pale-yellow. This latter variety is a poor kind but is the preferred variety in Costa Rica.

Cebolla (I, IV, and V, *Cebolla*). The sample of cebolla comprised 12 mature, dry, good quality bulbs ranging in size from 12 to 140 gm. For subsampling the onions were peeled and diced. The sample of *cebolla luciana* was made up of 13 good-sized single bulbs of about 60 gm. each. The outer or parchment skin was purplish. For subsampling the tops and outer dry leaves of the bulb were removed and a longitudinal wedge taken from each bulb.

Chayote, raíz de (I, *Pataste*). Six fresh, clean roots made up the sample. These were peeled, cubed, and mixed for subsampling.

Nabo (II, *Nabo*). The turnip originated in Europe or adjacent Asia but is now cultivated in most parts of the world. Sample (a) comprised nine fresh, mature roots of about 110 gm. Sample (b) consisted of eight fresh roots. Roots of both samples had white skins with a purplish tinge near the top. The flesh of those of Sample (b) was white, firm, and quite moist. For subsampling the roots of both samples were trimmed, peeled, diced, and mixed.

Ñampy or *ñampi.* The dasheen, or taro, a native of the East Indies, is now widely distributed over the tropics and subtropics of the world, and is in cultivation in some places outside of the tropics. The plant has become naturalized along streams and in moist places and it is probably from plants growing in such places that tubers found in markets of Central America are taken. This food appears to be used more extensively in Costa Rica than in the other countries of Central America. It is cooked by boiling and may be eaten in this form or used in soups and in various other ways. Sample (a) consisted of 12 roots of about 190 gm. each. The skin was dark-brown, with fibrous rings. Fifteen mature, medium-sized roots made up Sample (b). These had brown skins and white, fairly moist flesh. The roots of each sample were peeled, diced, and mixed for subsampling.

Papa (I, *Papa*). All samples were grown in the vicinity of Cartago. Potatoes grown on the slopes of the Volcán Irazú are very fine and equal to those of the Quezaltenango Valley in Guatemala. Some are exported.

The sample of *blanca estrella* consisted of 12 good quality potatoes weighing 80 to 100 gm. each. The skins were cream-white and the flesh clear white. Sample (a) of *papa morada* comprised 10 fair-sized tubers with purple skins and moist, white flesh. These are very common in all markets of Costa Rica. Sample (b) of this variety consisted of 10 good-sized, 120-gm. tubers, recently dug. Skins were purple and the flesh white and quite moist. The sample of *papa estrella* consisted of eight large, mature, new potatoes with purple skins and white flesh. The potatoes of each sample were peeled, diced, and mixed for subsampling.

Puerro. Leeks are native to the Old World, possibly to the Mediterranean region, and have been cultivated for their bulbs and for medicinal purposes since ancient times. They are of little importance in the Central American dietary and are seen in the markets only occasionally. Nineteen fresh, mature leeks of good size and with very strong flavor made up Sample (a). Sample (b) consisted of six fine large ones. For subsampling the tops and outer covering of the bulbs were removed and the bulbs chopped and mixed. Those of Sample (b) had some green color after trimming.

Rábano (I and II, *Rábano*). Sample (a) comprised 40 fresh tender roots with red skins and white flesh. These were trimmed, washed, dried, and then chopped for subsampling. Sample (b) consisted of small, round, red, young roots. For subsampling these radishes were topped, washed and dried, trimmed of roots, and cut in half.

Raíz (I, *Pataste*). See *Chayote, raíz de*. The sample of chayote consisted of six pieces of freshly dug roots. These were mature to use. For subsampling they were peeled and diced.

Remolacha (V, *Remolacha*). The 12 roots of Sample (a) of beets were of good quality, fresh, and clean. Ten good-sized mature roots of the common variety of beet made up Sample (b). These roots were of good quality with quite moist, tender flesh. For subsampling the roots were trimmed, peeled, and diced.

Salsifí (II, *Salsifí*). The oyster plant is native to southern Europe, where it has been in cultivation for a long time. It is of little importance as a food plant in Central America. The sample consisted of about 30 fresh, mature roots. For subsampling the tops were cut off and the roots scraped and chopped.

Tequisque (I, *Malanga*). The roots of this plant, more commonly called *malanga*, are difficult to distinguish from those of the taro *(Colocasia esculenta)*, but the plant may be distinguished easily by the sagittate leaf. Sample (a) consisted of six roots of about 245 gm. each, and Sample (b) of 12 mature roots with moist, white flesh streaked with purple. The roots were peeled and diced for subsampling.

Yuca (I and V, *Yuca*). Sample (a) was made up of 10 ripe, freshly dug roots with brown skins and white flesh and averaging 230 gm. each. Sample (b) consisted of five mature roots with brown, scaly skins and white flesh. These roots were of inferior quality. For subsampling all roots were peeled so as to remove the brown skin and the layer just beneath it, then diced.

Zanahoria (I and V, *Zanahoria*). Eleven rather small normal roots of the half-long type made up the sample. Large quantities of this variety are

exported to Panama from Cartago. After trimming, the roots were peeled and diced for subsampling. When being prepared for cooking they would not necessarily be peeled, but this was done in the case of the samples to assure removal of fine volcanic earth.

HERBAGE VEGETABLES:

Acelga (I, *Acelga*). Chard is considered to be a variety of beet. It is known to have been used since about 300 B.C. and is the oldest type of the beet group in cultivation. The sample consisted of about 500 fresh, good quality leaves. These were washed, superficially dried, and trimmed before being chopped for subsampling.

Apio (II, *Apio*). Celery is native to Europe and much of Asia and is found in moist or boggy places. The plant has been in cultivation for some 2,000 years but only recently has it come into common usage with the development of better varieties. The sample consisted of five bunches. The stalks were small, rather stringy, and not blanched. This celery was fresh, but inferior in quality. For subsampling the stalks were topped, cleaned, and chopped.

Berro (II, *Berro*). Watercress is native to Europe and Asia, and is now naturalized in streams throughout the world. Sample (a) consisted of 200 to 300 fresh stems in prime condition. These were washed and superficially dried and then chopped for subsampling after the hard stems and older leaves had been removed. Sample (b) comprised about 1,000 young plants. For subsampling the growing points were cut off and chopped.

Brocoli. Broccoli, like cauliflower, is presumed to have originated in the Mediterranean area, probably as a cultigen. The cultivated forms of *Brassica oleracea* are difficult to differentiate botanically. The cauliflowers and broccolis, for example, bear the same botanical name. Broccoli is grown commonly in Costa Rica but in small patches. It is not greatly appreciated and appears in markets mainly on principal market days. Sample (a) comprised fresh, young plants in fine condition with about 50 small flower groups. For subsamples the flower bunches, tender leaves, and upper parts of stems were removed and chopped. Sample (b) contained about 50 fresh stalks in optimum condition. After washing and drying, the flowers, tender leaves, and stems were removed and chopped for subsampling.

Chayote, puntas de (I, *Pataste*). A large number of growing points of this plant were purchased for the sample. For subsampling the tender points, tendrils, and leaves were chopped and mixed.

Col de Brusela (II, *Brusela*). Sample (a) comprised about 1,000 small heads of Brussels sprouts. They were fresh but not very good in quality. Whole heads were taken for subsamples. Several hundred small, mature, fresh heads made up Sample (b). They were washed and left to dry four hours and then trimmed rather thoroughly before subsamples were taken.

Coliflor (I, *Coliflor*). The close relationship between the history of cauliflower and broccoli has already been discussed under *Brocoli.* Cauliflower, like broccoli, is not a popular vegetable in Costa Rica, is seen in markets only on principal market days, and is quite expensive. It is used in soups and stews and is often eaten pickled.

Escarola (II, *Lechuga*). Eight bunches of fresh lettuce made up the sample. The inner leaves were blanched and the outer ones were normal green. All of them could have been used. The material was washed and dried after removal of old leaves and roots; the good leaves were chopped for subsampling.

Espinaca (I, *Espinaca*). Each sample consisted of about 200 fresh stems from mature plants. For subsampling of each sample the younger leaves and apical parts of stalks were removed and chopped. The material of Sample (a) was washed and dried.

Espinaca de Victoria. Spinach is native to southeastern Asia and has probably been in cultivation at least 1,000 years. In Central America spinach is not grown to any extent, perhaps due to lack of interest in greens, as well as to the fact that it is difficult to grow. The name *espinaca*, used without modification, invariably refers to New Zealand ice plant. When used to refer to true spinach it is modified by a word having the principal meaning of "true," as in this case, *espinaca de Victoria.* For subsampling the sample was washed and dried, trimmed of damaged leaves, and the roots and leaves chopped and mixed.

Itabo, flor de or *flor de itagua* (II, *Izote, flor de*). This species of yucca is native to Mexico and probably also to Guatemala. Sample (a) consisted of five racemes of flowers, some flowers open, and some still in bud. The flowers were removed and mixed but not chopped. Sample (b) was made up of four inflorescences, with the terminal flowers in bud and the lower ones green. The inflorescences were washed and drained two hours, and the flowers removed and mixed for subsampling.

Lechuga (II, *Lechuga*). The lettuces are believed to have been derived from a wild plant, *Lactuca Scariola*, in Asia. The cultivated types are not known in a wild state. Although lettuce has been in cultivation for somewhat over 1,000 years it has only recently become popular. Five very loose heads of young, good quality lettuce made up the sample of *lechuga de mantequilla.* The heads were washed, trimmed, and drained two hours, after which the leaves were chopped and mixed for subsampling. The sample of *lechuga romana* comprised 10 bunches of fresh lettuce with upright columns of leaves. After trimming away the poor leaves and roots, the remaining leaves were washed and dried superficially, then chopped for subsampling.

Mostaza. This plant is a cultigen of uncertain origin. It is used in Costa Rica as a green. The sample consisted of five bunches of fresh plants in good condition. These were washed and dried superficially, then chopped and mixed for subsampling.

Pacaya. This plant is native to the wet forests on the Atlantic slopes from Costa Rica to Honduras. The tender growths are boiled and used as a vegetable, in salads or pickled. The sample consisted of 10 pieces of the terminal part of the stem. The tender parts were removed and diced for subsampling.

Palmito. This tree is native to Costa Rica and is not known elsewhere. It is said to be common along the Atlantic coastal forest area, but the cutting of the tree for food will undoubtedly reduce its numbers. The edible part consists of the tender new growth of the terminal section, which

is about 18 inches long. The inside is soft and white. The sections are usually roasted but may be boiled. The tender part is then removed and used as a vegetable or in salads. Two entire "cabbages" from two trees made up the sample. The tender parts were chopped and mixed for the subsamples.

Perejil (IV, *Perejil*). There were about 1,000 fresh leaves in the sample. These were washed and dried two hours and the tender parts cut off, chopped, and mixed for subsampling.

Repollo (I, *Repollo*). The cabbages, along with their allies, the kales, collards, Brussels sprouts, cauliflower, and broccoli, are one of the oldest and most important of the cultivated vegetables. The cabbages show a range of variation hardly surpassed by any other vegetable, there being some 500 horticultural forms in cultivation. Sample (a) comprised six fresh, hard heads of common cabbage, varying in weight from 170 to 1,070 gm. The heads were cleaned, stripped of outer leaves, and cut in half longitudinally. The halves were then chopped and mixed for subsampling. Sample (b) consisted of four firm, mature heads with green outer leaves and white inner ones. After trimming, the entire heads were chopped and mixed. Ten small, firm, mature heads in good condition made up the sample of *repollo morado*. The leaves were superficially purple. The outer leaves were removed and the remainder chopped and mixed.

Repollo de China (I, *Repollo chino*). Five large, fresh stalks were purchased for the sample. Four inner leaves from each stalk were washed and dried, the fleshy mid-rib removed, and chopped and mixed for subsampling.

Súrtuba. This palm is native to Costa Rica, where it is said to be abundant in the forest area of the Atlantic slope. The "cabbages" are sold commonly in the highland markets. The raw cabbage is bitter and remains somewhat so after cooking. The edible portion is white and quite moist. It is used as a cooked vegetable or in pickles. Two mature cabbages from wild palms made up the sample. The tender part was diced for subsampling.

FRUIT VEGETABLES:

Aguacate (I, *Aguacate*). All samples were of the West Indian race of avocados. Sample (a) consisted of eight ripe fruits with relatively thin skins and cream-yellow, moist flesh. Ten small ripe fruits, having greenish-yellow, moist flesh, made up Sample (b). These fruits were of good flavor. Sample (c) consisted of six ripe fruits with dark-purple skins and greenish, moist flesh of fine flavor. Fruits of Sample (a) were peeled and seeded and wedges taken from each for the subsamples. For subsampling of the other two samples the flesh was spooned from the shell and mixed.

Ayote tierno; zapallo (I, *Ayote*). Sample (a) of squash consisted of five very immature fruits of about 400 gm. each. Longitudinal wedges from the whole fruits, including skin, flesh, and seeds, were used in the subsamples. Sample (b) consisted of five nearly mature fruits of the necked variety with green-black skins, cream-yellow flesh, and soft seeds. These were peeled and the flesh, including seeds, diced for the subsamples. The sample *zapallo* was made up of 10 very immature fruits of 100 to 200

gm., with soft skins and tender, watery flesh. Wedges from the outside to the center and including skin, flesh, and seeds were used in the subsamples.

Berengena (I and V, *Berengena*). Eight rather small, fresh, ripe fruits made up the sample of eggplant. The skins of the fruits were purple. For subsampling the fruits were peeled and the flesh with seeds diced.

Caiba (II, *Caiba*). Sample (a) consisted of 34 fruits at the proper stage for use as a vegetable. Sample (b) contained 30 tender, mature fruits with green, moist flesh. For subsampling the seeds and placentas were removed and the flesh diced. The fruits of Sample (b) were washed and dried.

Chayote tierno (I, *Pataste*). Six mature fruits of the chayote made up the sample. These had pale-green skins and very pale-green, moist, firm flesh and were almost spineless. For subsampling the fruits were peeled and the flesh diced.

Chile dulce (I, *Chile dulce*). Sample (a) of sweet pepper included excellent quality ripe fruits, more red than green. Sample (b) comprised 17 fair-sized, ripe fruits. The flesh was about three-fourths red, moist, and sweet. For subsampling of each sample the stems and seeds were removed and the flesh chopped and mixed.

Chile picante (II, *Chile guaque*). In origin the "chile pepper" is probably American and probably a cultigen. The hot peppers are not used as commonly in Costa Rica as they are in Guatemala and are much less evident in the markets. The sample comprised about 40 ripe fruits, approximately one-third of which were red and the remainder green. These were very hot chiles. The fruits were washed and dried, the stems, seeds, and placentas removed, and the flesh chopped and mixed.

Chiverre (II, *Chilacayote*). Five small, very immature fruits made up the sample. These weighed about 300 gm. each. When mature the fruits may weigh up to 15 kilos. The fruits were washed and dried and longitudinal wedges, including skin, flesh, and seeds, taken for the subsamples.

Pepino (V, *Pepino*). Sample (a) consisted of 10 cucumbers of the ordinary garden variety, at a stage suitable for use as a vegetable. These were peeled and longitudinal wedges taken for the subsamples. Sample (b) was made up of eight rather small, firm, green, tender fruits. The flesh was pale-greenish-white. For subsampling the fruits were peeled and the flesh with seeds diced.

Tomate (II and V, *Tomate*). Sample (a) consisted of seven very fine fruits. These weighed about 150 gm. each and were almost completely ripe. Wedge-shaped longitudinal slices, including skin, seeds, and pulp, were used in the subsamples. Sample (b) was made up of 10 ripe fruits averaging about 130 gm. These grew during the dry season. The fruits were washed and dried and the entire lot slurried, after which subsamples were taken.

Zapallo. See *Ayote tierno.*

CEREALS:

Maíz maicena (I, *Jilote*). The sample comprised eight ears of white dent corn in the late milk stage. For subsampling the kernels were cut from the cobs and mixed.

LEGUMES:

Alverja (III, *Alverja*). The garden pea originated perhaps in western Asia and was cultivated fairly widely in ancient times. No wild ancestor is known. In Central America it is grown successfully only at relatively high elevations. The peas of Sample (a) were at the immature, tender stage and when purchased were shelled, as are most peas seen in markets of Costa Rica. Several hundred mature, fresh pods made up Sample (b) from which the peas were shelled and mixed. Subsamples were taken from the lots after mixing.

Bainica mantequilla (I, *Habichuela*). Sample (a) consisted of fine, fresh wax beans at a stage suitable for stewing. Sample (b) consisted of a large number of pods. These were at a stage of maturity common for snapbeans sold in Costa Rica, but were more mature than snapbeans usually found in U. S. markets. The pods of both samples were washed and dried, and after the ends were removed were chopped and mixed for subsampling.

Bainica verde (I, *Habichuela*). About 800 good quality, tender pods made up the sample. These were washed, dried, trimmed, chopped, and mixed for subsampling.

Frijol tierno (I, *Habichuela*). The sample was a mixture of several varieties of beans, but principally red beans. They were ripe but not mature. These beans have a distinctive flavor and do not take long to cook. The subsamples were taken as whole beans from the mixture after the entire lot had been washed and dried.

Guapinol. This tree is native from Mexico, through Central America to northern South America. It is cultivated in many places in the tropics, principally as a shade tree but also for the fruits. The mature seed is surrounded by a dry, powdery pulp which may be eaten, or mixed with sugar and water as a drink. The sample consisted of 20 large, mature pods. These were broken open with a hammer and the dry pulp separated from the seeds at considerable expenditure of time.

FRUITS:

CITRUS:

"Grapefruit" (V, *Toronja*). The sample included five fair-sized, ripe fruits having rather thick skins. They were juicy, fairly sweet, and of good flavor. The sections were cut out with a knife, freed of seeds, and slurried. Subsamples were taken from this mixture.

Limón (I, *Lima limón;* V, *Naranja lima*). Sixteen ripe fruits made up the sample. The juice was expressed by hand and mixed for subsampling.

Mandarina (I, *Mandarina*). Good quality tangerines are to be found in Costa Rica although they are expensive. The tangerine will withstand a drier climate than other citrus fruits and more attention might be given to its cultivation. Sample (a) consisted of 12 ripe fruits of excellent quality and Sample (b) of nine ripe, juicy fruits with orange-red skins and deep-orange flesh. For subsampling the fruits of each sample were peeled and sections removed and freed of seeds.

BANANAS AND PLANTAINS:

Banano (V, *Banano*). Sample (a) consisted of 16 fruits, four from each of four stems. The fruits were of optimum ripeness and about 150 gm.

each in weight. These fruits may be boiled or fried, as well as eaten as a fruit out of hand. Sample (b) consisted of 11 fruits taken from four hands. They were of optimum ripeness but not of good export quality. For subsampling of each sample the bananas were peeled and mashed together.

Plátano (I, *Plátano*). The sample of *plátano* consisted of nine plantains about 10 inches long and of optimum ripeness. The flesh was cream-yellow and rather moist but firm. The sample of *plátano curare* comprised six fruits of about 300 gm. each. These were fully ripe with pale-golden-yellow, moist flesh. The fruits of each sample were peeled and mashed together for subsampling.

OTHER:

Anona (III, *Anona*). The custard-apple tree is commonly cultivated for its fruits, which are used as a fruit out of hand or to flavor ices and drinks. Six mature, ripe fruits made up the sample. The flesh was white or tinged with yellow, soft, moist, fragrant, and of good flavor. For subsampling the flesh, spooned from the shell of each fruit, was mashed together and the seeds removed.

Caimito (III, *Caimito*). Twelve rather small, ripe fruits of the star apple were purchased for the sample. The flesh was removed from the skin, freed of seeds, and then mixed. Subsamples were taken from the mix.

Chiverre (II, *Chilacayote*). See also under Fruit Vegetables. The flesh of this fruit with sugar, ginger, and other spices is made into a sweet. One mature, ripe fruit made up the sample. The flesh was white, firm, and moist, and the seeds black. The shell was broken with a hammer and the flesh, free of seeds, taken from various parts and mixed for subsampling.

Coco. Four mature fruits made up the sample. The flesh of each was firm and hard except for a thin inner layer. The "milk" was drawn off and portions of flesh from each fruit chopped together. Subsamples were taken from the mix.

Coco, leche de. Coconut "milk" serves as a source of uncontaminated water. The sample came from the nuts used for the sample of coconut meat.

Durazno. The sample comprised 16 small peaches of the clingstone variety. They were hard and mostly green, but not much different from those generally seen in Central America. They are usually prepared by cooking in a very heavy syrup. For subsampling the fruits were peeled and the flesh removed from the seeds, chopped, and mixed.

Fresa. The strawberry commonly grown in Central America seems to be the European species, or everbearing type. In Costa Rica it is found in some quantity near Cartago and San José. It is used as dessert or to make wines and jams. It commands a relatively high price in the markets. The fruits in Sample (a) were fresh, ripe, red, and of rather even size, about three gm. each. Fruits in Sample (b) were also ripe and were purchased the same day as picked. The fruits of each sample were hulled, washed, dried, and whole berries taken for the subsamples.

Granadilla (III, *Granadilla*). There were 16 ripe fruits in Sample (a) of granadilla and 14 in Sample (b). The outer shells of the latter were

orange-red. For subsampling of each sample the hard outer shells of the fruits were broken open and pulp and seeds removed and slurried.

Guanábana. The soursap is undoubtedly native to tropical America and is probably widely dispersed over the area, possibly since long before discovery of the continent. This fruit is much appreciated in Central America. The price of it in the markets is high, possibly due to the fact that the tree is a shy bearer. Two fairly large, ripe fruits made up the sample. The flesh of each was white, moist, and acidulous. Longitudinal wedges of flesh, free of skin and seeds, were taken for subsamples.

Higo (III, *Higo*). There were 36 figs in Sample (a). These were unripe, green, and rather small, although normal for Central America. Most figs grown in Costa Rica come from around Cartago. They are eaten candied or boiled in a heavy sugar syrup. Sample (b) consisted of 25 green fruits with dry, white flesh and skins with some purple color. For subsampling the hard stems were cut off and the remainder diced and mixed.

Icaco (I, *Icaco*). The *icaco* is native all along the shores from Mexico to Panama, in the West Indies, Florida, and northern South America. The fruit is not highly esteemed. It is eaten as a fruit out of hand or used to make cooling drinks and preserves. The sample contained about 60 fruits of the variation with light-colored skins. The flesh was white, fairly moist, and firm. The fruits were washed and dried, and the flesh and skin cut away from the seed and mixed for the subsamples.

Jocote (III, *Jocote*). The sample of Spanish plum contained about 100 ripe fruits with green-to-red skins. The flesh of these was yellow, moist, and of fine flavor. The fruits were washed and dried and the flesh cut away from the stone and mixed. Subsamples included skin and flesh.

Mango (I, *Mango*). Sample (a) of *mango caribe* comprised 12 medium-sized, good quality, ripe fruits of about 160 gm. each. The flesh was peach-color, moist, and had considerable fiber, but was of good flavor. There were seven ripe fruits in Sample (b) of *mango caribe*. The skins were mostly red with some green color; the flesh was apricot-colored, moist, of fine flavor, and with little fiber. The sample of *mango criollo* comprised 10 green, immature fruits. The flesh was very pale-yellow, moist, and firm. For subsampling of each sample the fruits were peeled and the flesh cut from the seed, diced, and mixed.

Manzana de agua (IV, *Marañón japonés*). The sample comprised 24 ripe fruits with orange-red skins and white, spongy flesh. These were washed and dried, seeds removed, and flesh and skins chopped and mixed. Subsamples were taken from the mix.

Manzana rosa. This fruit is rather insipid. The tree is native to southeastern Asia from where it has spread to the tropics of the world. It is cultivated possibly as much for its handsome foliage as for its fruit. Twenty-five ripe fruits were purchased for the sample. These had pale-green skins and pale-green, moist, fairly firm flesh. The fruits were washed and dried; the skin and flesh, freed of seeds, were broken into small pieces and mixed for subsampling.

Marañón (IV, *Marañón*). Sample (a) comprised 15 ripe "fruits." After washing and drying, these were chopped and mixed for subsampling.

Twelve fruits were purchased for Sample (b). These were large, fine, ripe fruits with red skins and pale-yellow flesh. They were washed and dried; longitudinal wedges were taken for the subsamples.

Mora. This blackberry is native to Costa Rica and Panama. Probably all of the fruits in markets are from spontaneous plants growing in thickets or along the edges of clearings. They may be used as a fruit but are more commonly made into preserves or wine. The sample contained about 1,000 ripe, black, moist fruits. These were relatively small, with many divisions and relatively large seeds. The fruits were washed and left to dry before subsampling.

Papaya (III, *Papaya*). Two fruits weighing 3.5 and 4.5 lb., respectively, were purchased for Sample (a). These had been ripened without scoring the skin. For subsampling longitudinal wedges were peeled, seeded, diced, and mixed. Sample (b) also consisted of two fruits ripened without scoring. One had apricot-colored flesh and the flesh of the other was redder. They were cut open longitudinally, the skins and seeds removed, and the flesh slurried. Subsamples were taken from the slurry.

Pejibaye. Relatively little is known about the *pejibaye* palm. Conditions of growth in Costa Rica leave some doubt as to whether it is native there or of an ancient introduction. The same species grows in Colombia and Brazil. Fruits of this palm are much appreciated as food in Costa Rica and form an appreciable item in the diet of country people. They are usually cooked by boiling and are often sold cooked, and are eaten out of hand or in salads. Sample (a) comprised high quality fruits. These were peeled and seeded and the flesh chopped and mixed for subsampling. Sample (b) was made up of 50 mature fruits. These were cooked. The flesh was yellow, rather dry, but of good flavor for *pejibaye.* For subsampling the seeds were removed and the flesh and skins chopped and mixed.

Piña (I, *Piña*). Sample (a) contained three vine-ripe fruits of about 2,000 gm. each. The flesh was juicy, white, and sweet. Longitudinal wedges were peeled, diced, and mixed for subsampling. Three fair-sized, ripe fruits made up Sample (b). These were the white-fleshed variety. The leaves were spineless. Longitudinal slices were peeled and slurried, and subsamples taken from the slurry.

Sandía (V, *Sandía*). Two relatively small, ripe fruits were in the sample. The flesh was red but not very firm. The flesh from one-half of each fruit was freed of seeds and mixed for subsampling.

Sapote. The sample consisted of six ripe fruits 15 to 20 cm. long. The rinds were brown; the flesh was yellow or orange-yellow, soft, sweet, with some fiber, and of not too good quality. For subsampling the large seed was removed from each fruit and the flesh then scooped out of the rinds and mixed together.

Tacaco. The tacaco is native to the highlands of Costa Rica but is not known to be cultivated elsewhere. It is cultivated occasionally for its fruits, which are used much as are chayotes. The fruits seen in markets were hard and full of fibers, although the amount varied greatly from fruit to fruit. There were 35 hard, nearly mature fruits. The seeds were round and softer than the flesh. There were 20 to 25 short, hard spines at the

base of each fruit. For subsampling the fruits were peeled and the flesh and seeds chopped and mixed.

Yas (IV, *Chucte*). These fruits have a very large seed and rather thick peel. They are eaten as a fruit out of hand or used in salads. Sample (a) comprised 10 mature fruits. The flesh was dark-to-greenish-brown. For subsampling the fruits were peeled, the large seed removed, and the flesh mixed. There were 11 ripe fruits in Sample (b). These fruits were different from the species usually seen in Costa Rica. The peel was stripped off, the flesh scraped from the seed, and mixed. Subsamples were taken from the mix.

Zapote (I, *Zapote*). Three fine, ripe fruits weighing 750 to 875 gm. were purchased for the sample. The skins were russet color and rough; the flesh was dull-brick-red in color, and soft. The skins were stripped off, the seed removed, and the flesh mixed. Subsamples were taken from the mix.

Zapote (III, *Injerto*). The sample consisted of five large, ripe fruits. The skins were green, with obvious lenticels or pores; the flesh was orange yellow. The flesh was scooped out of the shells and mixed.

DRY SAMPLES:

CEREALS:

Arroz (III, *Arroz*). The sample of dry rice was purchased in the market in San José.

Maíz blanco (I, *Jilote*). This white corn is the variety used for tortillas. The sample had been treated with DDT powder.

Maíz de Guinea (IV, *Maicillo*). The sample of kafir corn was purchased in the San José market.

LEGUMES:

Cubá (III, *Piloy*). Beans of this type are common in Costa Rica, but they do not seem to be so important in the diet there as they are in Guatemala. They are usually eaten boiled. Both samples, one of white and the other of yellow beans, were purchased in the San José market. Both were treated with DDT powder for shipment, to avoid damage by beetles.

Frijol (I, *Habichuela*). The 16 samples of beans purchased in Costa Rica represent a variety of forms of this food. *Frijol bainica* is a small, tan-colored bean probably used more often as a snapbean than as a dry, shelled bean. *Frijol blanco* is a very small, white bean. *Frijol chileno* is one of the more common beans. They are of medium size and maroon color. *Frijol chimbolo* is also a common bean, very similar to *frijol bolonillo* of Guatemala. It is very small with shiny black seed coat. *Frijol guaria* is also one of the common beans. They are medium-sized and red in color. *Frijol Higuerillo* is an uncommon type of bean. It is small, about the size of *frijol bainica*, and brown-to-tan in color with strong, parallel, reddish-brown markings. *Frijol Jamaica* is a long, slender, medium-sized bean, tan in color with scattered reddish markings varying in intensity from very light to very dark. *Frijol kuibra* is one of the fairly common types of red beans. They are about the size of *frijol bainica* and dark-red in color. *Frijol de mantequilla* is a long, slender, medium-sized bean similar in shape and size to *frijol guaria*. Their color, a dull tan, is most unattrac-

tive. *Frijol negro corriente* is the most common of the black beans. They are very small and dull black in color. In the opinion of one of the authors, the flavor of this bean is inferior to that of other black beans. *Frijol norteño* is a long, slender bean of medium size, reddish-brown in color with scattered tan markings more pronounced near the hilum. *Frijol parranda* is one of the uncommon beans. They are very small, somewhat flattened, and have a shiny seed coat. The predominant color is reddish-brown mottled with faint, lighter brown striations tending to converge toward the hilum. *Frijol portoto* resembles the *frijol Jamaica* in color and markings, but is smaller and is relatively shorter and thicker. *Frijol portugués* is one of the more uncommon beans in the market. This is a small "squarish" bean with a dull, dark-reddish-brown color mottled with very faint irregular tan markings. *Frijol Sangre de Cristo* is an uncommon bean. It is small and rather thin. Its shiny, dark maroon-colored seed coat makes it very attractive. *Pisque* is an uncommon bean and a rather expensive one. In size and shape it resembles *frijol de mantequilla* very closely. The color, however, is much more pleasing. It is a bright tan with very faint, slightly darker striations converging toward the hilum. All samples except that of *frijol Higuerillo* were treated with DDT powder for shipment.

Frijol de arroz. The rice bean is native to southeastern Asia, where it is still found in the wild state. It is now planted in the tropics and the subtropics as a cover crop or as fodder. It is not grown commonly in Central America although it is to be found in many large markets. It is not an important item of the diet. It is a small bean and easily distinguished by the large, white, linear hilum. The pods tend to shatter easily, resulting in considerable loss during harvesting, which may account in part for its lack of popularity as a food crop.

Frijol de ojo negro; frijol ravisa (I, *Frijol de vaca*). Cowpeas are rare in Costa Rica. The two samples were purchased in the San José market. The sample *frijol de ojo negro* was treated with DDT powder for shipment.

Pisque. See *Frijol.*

BERRY:

Café en grano (III, *Café*). Coffee is an important export for Costa Rica, as it is for the other countries of Central America. The sample was high-grown coffee, one of the best grown in Costa Rica.

MISCELLANEOUS:

Rábano de caballo. Horseradish is most probably native to southeastern Asia and was early established in temperate climates. As a weed it is hard to extirpate. The plant does not grow too well in Central America. The part used is the root, most commonly as a condiment with meats. It was seen only once in markets of Costa Rica and the price was exorbitant—$1.40 per lb. The sample consisted of small, fresh roots. These were washed but not peeled, then chopped for subsampling.

Ruibarbo (II, *Ruibarbo*). Rhubarb is native to Asia, where it is still found in the wild state. Cultivated rhubarb is considered by some to be a hybrid. The plant is rare in Central America and probably will never be very popular because of its acid flavor. Sample (a) comprised eight very

large, fine, fresh leaf stalks. These were washed, dried, and diced for subsampling. Ten good-sized, mature stalks made up Sample (b). These were somewhat pithy. For subsampling the stalks were trimmed, the skins removed by stripping, and the remainder chopped.

Tapa de dulce (IV, *Jugo de caña*). The sample consisted of a two-pound brick of sugar. This was fine and clear.

RESULTS AND DISCUSSION

Identification of the 154 samples and the amounts of the various constituents found per 100 gm. of edible material are shown (Table 2). A number of the foods are of interest because of their high content of one or more nutrients. Where there was more than one sample of a food, considerable variation was shown in composition from sample to sample in some cases. These results are considered in the discussion that follows.

Fresh Foods:

Among the Earth Vegetables were a number of samples which contained noticeable amounts of ascorbic acid: *camote* (36.6 and 36.8 mg.), *nabo* (28.7 and 30.4 mg.), *papa* (32.6, 22.9, 34.9, and 27.8 mg.), *rábano* (25.6 and 37.8 mg.), and *yuca* (34.2 and 35.7 mg.). The amounts derived from these foods would depend, of course, upon the method of preparation used. *Ñampy* and *papa* also contained amounts of niacin that were not unimportant (1.220 and 1.532 mg., and 1.650, 1.184, 1.359, and 1.545 mg., respectively).

The group of Herbage Vegetables contained the largest number of foods with significantly high values.

Acelga contained important amounts of iron (2.97 mg.), of carotene (2.280 mg.), and of ascorbic acid (64.1 mg.).

Berro is represented by two samples. Both contained appreciable amounts of calcium (122.5 and 104.0 mg.), while one had a high content of carotene (2.100 mg.) and of ascorbic acid (63.0 mg.), and the other a high content of iron (3.86 mg.).

The two samples of *brocoli* contained considerable amounts of several nutrients: calcium (108.8 and 176.0 mg.), iron (1.83 and 3.39 mg.), carotene (1.702 and 2.013 mg.), thiamine (0.154 and 0.149 mg.), riboflavin (0.248 and 0.169 mg.), and ascorbic acid (163.6 and 110.8 mg.).

Puntas de chayote contained moderate amounts of several nutrients: iron (2.74 mg.), carotene (2.270 mg.), thiamine (0.119 mg.), riboflavin (0.208 mg.), and niacin (1.432 mg.).

Col de Brusela, like *brocoli*, gave high values for iron (3.71 and 3.23 mg.), thiamine (0.125 and 0.204 mg.), riboflavin (0.254 and 0.146 mg.), and ascorbic acid (63.8 and 84.0 mg.), and also for niacin (1.220 and 1.593 mg.). Values for carotene were low (0.548 and 0.021 mg.), as would be expected.

Espinaca gave high values for iron (3.52 and 4.36 mg.) and carotene (2.310 and 2.240 mg.). Whether the iron was in or on the plants was a question.

The one sample of *espinaca de Victoria* also gave high values for iron (3.92 mg.) and carotene (2.415 mg.).

TABLE 2

Composition of Food Samples From Costa Rica

Name of food sampled			Place of origin of sample	Constituents measured and yields per 100 gm.												
Spanish	Scientific	English		Moisture	Ether extract	Crude fiber	Nitrogen	Ash	Calcium	Phosphorus	Iron	Carotene	Thiamine	Riboflavin	Niacin	Ascorbic Acid-Total
	EARTH VEGETABLES			*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*
Ajo	*Allium sativum* L.	Garlic	Santa Ana	62.0	0.15	1.9	1.241	1.44	30.2	167.0	1.02	.002	.307	.087	.562	6.3
Camote (a)	*Ipomoea Batatas* (L.) Lam.	Sweet potato	San Antonio Belén	66.6	0.15	0.8	.356	1.09	23.1	79.6	0.98	.044	.181	.054	1.026	36.6
Camote (b)	*Ipomoea Batatas* (L.) Lam.	Sweet potato	Alajuela	65.3	0.13	0.9	.106	.90	24.8	61.0	0.59	.043	.119	.038	.795	36.8
Cebolla	*Allium Cepa* L.	Onion	Santa Ana de Escassú	91.0	0.09	0.3	.139	.35	24.2	27.9	0.53	.000	.031	.013	.109	9.2
Cebolla luciana	*Allium Cepa* L.	Onion	San Antonio Belén	88.9	0.10	0.6	.245	.41	25.4	25.5	0.37	.008	.052	.025	.268	15.2
Chayote, raíz de	*Sechium edule* (Jacq.) Sw.	Chayote root	Alajuelita	84.5	0.39	0.5	.332	.81	6.1	34.3	0.54	.018	.041	.028	.780	21.8
Nabo (a)	*Brassica Rapa* L.	White turnip	Cartago	92.1	0.20	0.9	.121	.35	22.4	18.4	0.20	.001	.033	.029	.498	28.7
Nabo (b)	*Brassica Rapa* L.	White turnip	Cartago	90.8	0.15	0.7	.108	.56	22.3	19.5	0.42	.000	.038	.023	.520	30.4
Ñampy (a)	*Colocasia esculenta* (L.) Schott	Taro	Naranjo	69.4	0.35	0.8	.321	1.21	15.5	34.2	0.59	.000	.111	.038	1.220	9.0
Ñampy (b)	*Colocasia esculenta* (L.) Schott	Taro	Alajuela	64.1	0.18	0.4	.400	1.00	10.2	58.2	0.95	.000	.151	.034	1.532	4.7
Papa blanca estrella	*Solanum tuberosum* L.	Potato	Cartago	81.3	0.26	0.5	.335	.82	3.0	28.2	0.34	.000	.095	.042	1.650	32.6
Papa estrella	*Solanum tuberosum* L.	Potato	Coté de Cartago	84.2	0.10	0.4	.354	.79	8.0	26.4	1.34	.005	.075	.030	1.184	22.9
Papa morada (a)	*Solanum tuberosum* L.	Potato	Cartago	82.4	0.17	0.4	.312	.83	2.5	24.4	0.48	.003	.068	.043	1.359	34.9
Papa morada (b)	*Solanum tuberosum* L.	Potato	Cartago	83.6	0.04	0.2	.357	.90	3.0	31.3	0.79	.000	.078	.044	1.545	27.8
Puerro (a)	*Allium Porrum* L.	Leek	Cartago	81.7	0.20	1.3	.216	.82	41.7	54.3	1.02	.045	.118	.071	.424	27.7
Puerro (b)	*Allium Porrum* L.	Leek	Cartago	81.5	0.20	1.4	.294	.42	57.3	40.3	1.02	.000	.104	.048	.468	9.2
Rábano (a)	*Raphanus sativus* L.	Radish	Cartago	94.5	0.11	0.7	.177	.77	18.9	25.3	0.70	.000	.033	.035	.271	25.6
Rábano (b)	*Raphanus sativus* L.	Radish	Alajuelita	94.6	0.08	0.5	.165	.78	17.7	28.2	0.70	.003	.031	.032	.399	37.8
Raíz	*Sechium edule* (Jacq.) Sw.	Chayote root	San Isidro Coronado	80.6	0.11	0.4	.238	.95	11.5	35.4	14.75	.002	.032	.025	.704	14.7
Remolacha (a)	*Beta vulgaris* var. *crassa* Alef.	Beet	Cartago	88.7	0.17	0.9	.271	.92	9.9	46.0	0.47	.003	.023	.037	.217	4.3
Remolacha (b)	*Beta vulgaris* var. *crassa* Alef.	Beet	Near Cartago	83.6	0.04	0.6	.363	.98	19.2	13.1	0.73	.005	.024	.031	.226	6.4
Salsifí	*Tragopogon porrifolius* L.	Salsify	Cartago	74.6	.027	1.9	.225	1.02	49.1	60.1	1.36	.000	.040	.041	.214	9.9

Tequisque (a)	*Xanthosoma violaceum* Schott	.....	Zarcero	64.1	0.27	1.7	.291	1.12	6.7	48.3	0.49	.012	.121	.045	.750	13.0
Tequisque (b)	*Xanthosoma violaceum* Schott	.....	Near San Carlos	60.2	0.23	0.5	.352	1.24	8.0	56.2	4.49	.003	.150	.042	.810	14.1
Yuca (a)	*Manihot esculenta* Crantz.	Manioc	Cartago	60.5	0.27	2.7	.107	.86	19.2	37.3	0.34	.002	.052	.031	.493	34.2
Yuca (b)	*Manihot esculenta* Crantz.	Manioc	Guápiles	64.9	0.25	0.9	.078	1.01	29.9	69.7	0.40	.001	.063	.031	.659	35.7
Zanahoria	*Daucus Carota* L.	Carrot	Near Cartago	83.4	0.07	0.9	.141	.82	38.5	28.9	0.52	7.882	.053	.037	.500	5.0
	HERBAGE VEGETABLES															
Acelga	*Beta vulgaris* var. *cicla* Moq.	Swiss chard	Cartago	89.7	0.43	1.4	.391	2.01	78.8	61.8	2.97	2.280	.103	.210	.608	64.1
Apio	*Apium graveolens* L.	Celery	San Pedro Montes de Oca	93.6	0.04	0.9	.149	1.25	42.4	21.2	1.13	.071	.029	.065	.276	12.4
Berro (a)	*Nasturtium officinale* R. Br.	Watercress	Taras	93.4	0.38	0.9	.357	1.29	122.5	46.3	0.91	2.100	.087	.149	.753	63.9
Berro (b)	*Nasturtium officinale* R. Br.	Watercress	Near Cartago	94.5	0.31	0.5	.346	1.01	104.0	39.0	3.86	.382	.087	.135	.853	29.8
Brocoli (a)	*Brassica oleracea* var. *botrytis* L.	Broccoli	Cartago	86.7	0.45	1.9	.777	1.25	108.8	94.8	1.83	1.702	.154	.248	.885	163.6
Brocoli (b)	*Brassica oleracea* var. *botrytis* L.	Broccoli	Near Cartago	87.0	0.41	1.5	.665	1.48	176.0	44.7	3.39	2.013	.149	.169	1.036	110.8
Chayote, puntas de	*Sechium edule* (Jacq.) Sw.	Growing points of chayote	Hatillo	87.8	0.49	1.4	.778	1.32	69.5	122.9	2.74	2.270	.119	.208	1.432	16.5
Col de Bruscla (a)	*Brassica oleracea* var. *gemmifera* Zenker	Brussels sprouts	Cartago	82.4	0.25	2.4	.749	1.49	58.7	91.3	3.71	.548	.125	.254	1.220	63.8
Col de Brusela (b)	*Brassica oleracea* var. *gemmifera* Zenker	Brussels sprouts	Near Cartago	81.1	0.17	2.2	.991	1.48	59.0	99.4	3.23	.021	.204	.146	1.593	84.0
Coliflor (a)	*Brassica oleracea* var. *botrytis* L.	Cauliflower	Coto	90.3	0.27	1.1	.424	.85	19.0	40.1	0.63	.033	.097	.093	.665	82.2
Coliflor (b)	*Brassica oleracea* var. *botrytis* L.	Cauliflower	Tierra Blanca de Cartago	89.3	0.16	1.1	.462	.92	30.6	59.4	1.19	.027	.117	.103	.729	89.7
Escarola	*Lactuca sativa* var. *intybacea* (Jacq.) Hort.	Lettuce	Cartago	92.4	0.36	1.0	.248	.99	34.8	32.8	0.96	1.035	.139	.094	.401	15.8
Espinaca (a)	*Tetragonia expansa* Thunb.	New Zealand iceplant	San Vicente de Moravia	93.1	0.35	0.8	.344	1.82	59.4	36.3	3.52	2.310	.048	.185	.397	30.8
Espinaca (b)	*Tetragonia expansa* Thunb.	New Zealand iceplant	Near Cartago	91.6	0.29	0.6	.453	1.64	71.6	38.3	4.36	2.240	.067	.150	.486	33.6
Espinaca de Victoria	*Spinacea oleracea* L.	Spinach	Cartago	92.3	0.41	0.9	.418	2.14	41.9	66.9	3.92	2.415	.107	.228	.486	25.7
Itabo, flor de (a)	*Yucca elephantipes* Regel	Yucca flowers	Alajuelita	81.9	0.38	1.3	.362	.86	40.4	68.0	0.99	.067	.182	.170	1.578	498.0

TABLE 2 *(Continued)*

Composition of Food Samples From Costa Rica

Name of food sampled			Place of origin of sample	Constituents measured and yields per 100 gm.												
Spanish	Scientific	English		Moisture	Ether extract	Crude fiber	Nitrogen	Ash	Calcium	Phosphorus	Iron	Carotene	Thiamine	Riboflavin	Niacin	Ascorbic Acid-Total
				gm.	*gm.*	*gm.*	*gm.*	*gm.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*
Itabo,flor de (b)	*Yucca elephantipes* Regel	Yucca flowers	Alajuelita	84.2	0.35	0.7	.264	.66	26.3	61.9	0.94	.043	.144	.078	1.466	343.0
Lechuga de mantequilla	*Lactuca sativa* var. *capitata* Hort.	Head lettuce	San Isidro Coronado	95.4	0.11	0.5	.178	.44	23.4	34.2	1.49	.348	.103	.070	.426	10.6
Lechuga romana	*Lactuca sativa* var. *romana* Hort.	Romaine lettuce	Cartago	93.8	0.17	0.9	.181	.69	28.2	41.4	1.03	.540	.080	.092	.426	8.7
Mostaza	*Brassica juncea* var. *foliosa* Bailey	Leaf mustard	La Sábana de San José	93.8	0.37	0.8	.269	1.29	97.7	35.4	1.35	1.723	.051	.094	.472	57.4
Pacaya	*Chamaedorea Pacaya* Oerst.	Pacaya	Eastern slopes Volcán Poas	84.3	0.39	1.9	.259	1.30	126.1	39.1	0.60	.006	.045	.050	.408	19.3
Palmito	*Euterpe longipetiolata* Oerst.	Palm cabbage	Turrialba	90.0	0.27	0.6	.543	1.40	92.3	86.4	0.73	.020	.046	.109	.716	20.1
Perejil	*Petroselinum crispum* (Mill.) Mansfeld	Parsley	Cartago	85.3	0.61	1.4	.594	2.00	191.2	44.8	14.25	.078	.139	.281	1.369	143.6
Repollo (a)	*Brassica oleracea* var. *capitata* L.	Cabbage	Zarcero	92.6	0.16	0.8	.223	.59	40.1	17.5	0.29	.005	.055	.047	.178	38.1
Repollo (b)	*Brassica oleracea* var. *capitata* L.	Cabbage	Near Cartago	92.1	0.10	0.8	.153	.44	32.3	14.1	0.34	.021	.029	.033	.174	42.4
Repollo morado	*Brassica oleracea* var. *capitata* L.	Purple cabbage	San Vicente de Moravia	89.2	0.23	1.5	.463	.98	50.4	50.5	0.74	.016	.142	.085	.384	95.8
Repollo de China	*Brassica pekinensis* (Lour.) Rupr.	Chinese cabbage	San Pedro Montes de Oca	95.8	0.08	0.4	.074	.59	33.5	22.3	0.39	.003	.009	.021	.366	26.0
Súrtuba	*Geonoma edulis* Wendl.	Palm cabbage	Eastern slopes Volcán Poas	88.2	0.27	1.5	.509	1.27	41.3	82.4	1.78	.006	.070	.125	1.207	18.2
	FRUIT VEGETABLES															
Aguacate (a)	*Persea americana* Mill.	Avocado	Near Puntarenas	87.7	5.13	1.4	.184	.66	12.3	46.4	0.38	.075	.056	.090	1.415	13.4
Aguacate (b)	*Persea americana* Mill.	Avocado	Orotina	84.3	7.69	1.1	.376	.72	11.8	39.3	0.80	.164	.033	.238	2.164	12.4
Aguacate (c)	*Persea americana* Mill.	Avocado	Orotina	83.6	7.97	1.0	.189	.56	13.1	24.3	0.52	.155	.057	.095	1.281	17.3
Ayote tierno (a)	*Cucurbita Pepo* L.	Squash, very immature	Cartago	91.9	0.18	0.4	.178	.53	12.6	28.8	0.43	.210	.041	.052	.532	19.0
Ayote tierno (b)	*Cucurbita Pepo* L.	Squash, very immature	Near Cartago	89.8	0.10	0.5	.177	.48	8.8	28.6	0.43	.039	.055	.052	.602	18.1

Berengena	*Solanum Melongena* var. *esculentum* (Dunal) Nees	Eggplant	San Juan en el Cantón de San José	90.2	0.08	0.7	.218	.56	8.0	36.0	0.94	.005	.051	.053	.857	7.7
Caiba (a)	*Cyclanthera pedata* Schrad.	.....	San Vicente de Moravia	94.8	0.04	0.7	.092	.92	12.3	10.3	0.22	.054	.058	.037	.197	11.7
Caiba (b)	*Cyclanthera pedata* Schrad.	.....	Near Cartago	93.8	0.03	0.8	.102	.82	15.7	13.5	0.39	.000	.058	.036	.244	14.4
Chayote tierno	*Sechium edule* (Jacq.) Sw.	Chayote	Orosi	91.7	0.10	0.7	.147	.31	9.7	21.4	0.33	.016	.025	.034	.404	20.8
Chile dulce (a)	*Capsicum annuum* var. *grossum* (L.) Sendt	Sweet pepper	San Antonio Belén	91.0	0.37	0.8	.173	.45	5.2	19.3	0.37	.219	.051	.061	.790	205.3
Chile dulce (b)	*Capsicum annuum* var. *grossum* (L.) Sendt	Sweet pepper	San Antonio Belén	90.7	0.38	0.8	.171	.28	2.8	13.9	0.24	.012	.063	.072	.815	236.5
Chile picante	*Capsicum annuum* var. *longum* (DC.) Sendt.	Hot pepper	Jiménez	91.5	0.14	1.7	.172	.52	6.1	23.6	0.57	.013	.054	.052	.820	99.4
Chiverre	*Cucurbita ficifolia* Bouché	.....	Cartago	92.7	0.08	0.4	.155	.51	18.2	32.2	0.35	.038	.041	.055	.449	34.5
Pepino (a)	*Cucumis sativus* L.	Cucumber	Cartago	96.3	0.19	0.4	.108	.38	10.5	26.2	0.21	.022	.025	.020	.140	16.8
Pepino (b)	*Cucumis sativus* L.	Cucumber	Siquirres	95.0	0.09	0.3	.122	.47	13.1	24.6	0.28	.011	.025	.031	.199	20.5
Tomate (a)	*Lycopersicum esculentum* Mill.	Tomato	San Antonio Belén	93.9	0.45	0.6	.168	.52	3.5	18.7	0.34	.453	.065	.038	.699	36.7
Tomate (b)	*Lycopersicum esculentum* Mill.	Tomato	Alajuelita	93.0	0.13	0.6	.146	.53	4.6	26.6	0.68	.485	.072	.038	.708	26.4
Zapallo	*Cucurbita Pepo* L.	Squash, very immature	Cartago	92.0	0.26	0.5	.222	.49	16.1	34.6	0.38	.091	.070	.054	.558	37.5
	CEREALS															
Maíz maicena	*Zea Mays* L.	Green corn	Turrialba	84.8	0.44	1.0	.461	.66	8.0	71.9	0.92	.009	.101	.100	1.250	18.1
	LEGUMES															
Alverja (a)	*Pisum sativum* L.	Pea	Cartago	70.2	0.45	3.1	1.350	.93	20.8	141.9	1.81	.110	.457	.148	2.515	27.0
Alverja (b)	*Pisum sativum* L.	Pea	Cartago	72.5	0.23	2.9	1.286	.95	22.4	152.5	1.67	.002	.316	.126	2.090	24.0
Bainica de mantequilla (a)	*Phascolus vulgaris* L.	Snap bean, wax	Cartago	90.3	0.26	1.2	.355	.73	42.4	45.6	0.88	.052	.071	.137	.647	9.8
Bainica de mantequilla (b)	*Phascolus vulgaris* L.	Snap bean, wax	Cartago	90.6	0.08	1.1	.308	.58	44.5	29.3	1.26	.026	.067	.087	.569	15.8
Bainica verde	*Phascolus vulgaris* L.	Snap bean, green	Cartago	91.2	0.23	1.1	.319	.64	40.5	43.0	0.79	.433	.092	.117	.477	22.0
Frijol tierno	*Phascolus vulgaris* L.	Fresh shell bean	Cartago	51.9	0.34	2.5	1.856	1.99	58.1	250.4	3.47	.007	.537	.123	1.845	10.1
Guapinol	*Hymenaea Courbaril* L.	Pulp around seeds	Heredia	14.6	2.18	13.4	.942	2.00	28.2	142.6	3.24	.005	.227	.173	4.120	11.4

TABLE 2 (*Continued*)

Composition of Food Samples From Costa Rica

Name of food sampled			Place of origin of sample	Constituents measured and yields per 100 gm.											
Spanish	Scientific	English		Moisture	Ether extract	Crude fiber	Nitrogen	Ash	Calcium	Phosphorus	Iron	Carotene	Thiamine	Riboflavin	Niacin	Ascorbic Acid-Total
				gm.	gm.	gm.	gm.	gm.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
	FRUITS															
	1. Citrus															
Grapefruit	*Citrus maxima* (Burm.) Merrill	Grapefruit	Santa Ana de Escassú	88.0	0.18	0.2	.110	.42	14.8	20.2	0.53	.003	.046	.017	.157	45.8
Limón	*Citrus limetta* Risso	Sweet lime	Villa de Colón	90.3	<0.01	<0.01	.064	.32	3.0	13.8	0.34	.000	.019	.012	.116	42.0
Mandarina (a)	*Citrus reticulata* Blanco	Tangerine	Near Santa Ana	85.6	0.28	0.7	.151	.53	33.4	20.8	0.33	.175	.128	.036	.199	21.3
Mandarina (b)	*Citrus reticulata* Blanco	Tangerine	Near Escassú	85.5	0.21	0.3	.161	.44	38.3	19.6	0.46	.052	.119	.032	.214	15.0
	2. Bananas and Plantains															
Banano (a)	*Musa paradisiaca* var. *sapientum* L.	Banana	Puerto Jiménez	72.2	0.18	0.5	.192	1.30	6.2	37.3	0.25	.128	.035	.061	.704	12.7
Banano (b)	*Musa paradisiaca* var. *sapientum* L.	Banana	Limón	74.0	0.21	0.2	.245	.74	3.4	26.0	0.80	.000	.025	.042	.810	7.8
Plátano	*Musa paradisiaca* L.	Horse plantain	Martina de Limón	58.8	0.02	0.4	.182	.78	4.5	50.3	0.60	.403	.065	.027	.687	19.2
Plátano curaré	*Musa paradisiaca* L.	Plantain	Turrialba	64.1	0.11	0.6	.213	1.20	4.0	50.3	0.41	.433	.102	.045	.668	22.4
	3. Other															
Anona	*Annona reticulata* L.	.....	Cartago	79.3	0.16	0.9	.252	.66	26.9	32.1	0.42	.018	.119	.175	1.190	44.4
Caimito	*Chrysophyllum Cainito* L.	Star apple	Orotina	78.4	2.01	2.0	.141	.38	13.4	15.9	0.30	.023	.037	.015	.935	15.2
Chiverre	*Cucurbita ficifolia* Bouché	.....	Zarcero	90.8	0.04	0.6	.086	.50	10.0	5.9	0.41	.001	.038	.015	.215	2.5
Coco	*Cocos nucifera* L.	Coconut meat	Near Limón	54.5	27.32	4.8	.556	1.00	6.2	112.8	1.76	.003	.027	.023	.765	3.5
Coco, leche de	*Cocos nucifera* L.	Coconut milk	Near Limón	95.6	<0.01	<0.01	.032	.45	19.0	13.4	1.21	.001	.001	.005	.067	0.8
Durazno	*Prunus persica* (L.) Sieb. and Zucc.	Peach	San Antonio de Escassú	86.4	0.20	0.5	.121	.45	6.0	23.9	0.65	.003	.031	.028	.321	11.2
Fresa (a)	*Fragaria vesca* L.	Strawberry	Cartago	91.7	0.11	1.1	.115	.38	22.4	25.3	0.75	.040	.033	.029	.255	69.5
Fresa (b)	*Fragaria vesca* L.	Strawberry	San Pedro Montes de Oca	92.1	0.09	1.0	.101	.40	22.6	21.3	1.49	.004	.026	.026	.277	71.2
Granadilla (a)	*Passiflora ligularis* Juss.	.....	Pacayas	76.0	3.18	3.7	.389	1.07	7.3	55.7	0.58	.020	.001	.103	1.481	28.1
Granadilla (b)	*Passiflora ligularis* Juss.	.....	Santa María Aserri	71.9	2.84	4.9	.463	1.12	8.8	70.4	0.66	.011	.000	.125	1.693	27.4

Guanábana	*Annona muricata* L.	Guanabana	Batán	83.9	0.22	1.0	.136	.49	23.0	19.8	1.34	.000	.059	.061	.548	18.9
Higo (a)	*Ficus Carica* L.	Fig	Cartago	88.2	0.11	1.5	.213	.71	39.2	32.9	2.12	.195	.049	.075	.386	31.6
Higo (b)	*Ficus Carica* L.	Fig	Near Cartago	90.1	0.14	1.3	.209	.48	36.8	29.3	4.09	.094	.034	.079	.412	17.0
Icaco	*Chrysobalanus Icaco* L.	.....	Near Limón	84.0	0.19	1.3	.055	.96	38.9	19.6	0.54	.007	.040	.023	.245	9.7
Jocote	*Spondias purpurea* L.	Spanish plum	Near Puntarenas	78.8	0.05	0.5	.118	.62	14.6	31.5	0.54	.004	.100	.045	.540	32.5
Mango caribe (a)	*Mangifera indica* L.	Mango	Orotina	84.1	0.17	1.0	.095	.36	11.8	13.2	0.22	1.018	.039	.037	.209	31.8
Mango caribe (b)	*Mangifera indica* L.	Mango	Puntarenas	81.7	0.17	0.9	.068	.40	15.2	15.1	0.27	1.819	.041	.045	.348	25.9
Mango criollo	*Mangifera indica* L.	Mango	Alajuela	88.3	0.10	0.5	.046	.36	11.6	9.2	0.25	.089	.023	.024	.183	69.5
Manzana de agua	*Sizygium malaccensis* (L.) Merrill and Perry	.....	Alajuela	90.5	0.13	0.8	.102	.40	7.7	16.6	0.29	.000	.030	.030	.330	12.8
Manzana rosa	*Sizygium Jambos* (L.) Alston	Rose apple	Puntarenas	80.4	0.08	1.0	.107	.37	28.2	16.7	1.96	.032	.027	.036	1.032	27.4
Marañón (a)	*Anacardium occidentale* L.	Cashew apple	Orotina	85.0	0.17	1.0	.127	.32	1.6	15.3	0.26	.476	.019	.020	.474	166.5
Marañón (b)	*Anacardium occidentale* L.	Cashew apple	Near San Mateo	86.7	0.23	0.5	.101	.33	0.9	16.9	0.66	.008	.018	.019	.514	200.3
Mora	*Rubus costaricanus* Liebm.	Blackberry	Santa María de Dota	79.5	1.53	5.7	.252	.65	63.1	35.1	19.50	.014	.021	.058	.435	21.3
Papaya (a)	*Carica Papaya* L.	.....	Guápiles	89.7	0.08	0.7	.118	.66	17.0	14.5	0.28	.192	.029	.058	.555	44.0
Papaya (b)	*Carica Papaya* L.	.....	Near Coyolar	85.9	0.11	0.7	.117	.51	15.4	21.6	0.30	.676	.034	.042	.470	71.3
Pejibaye (a)	*Guilielma Gasipaes* (HBK.) Bailey	Peach palm	Near Puerto Limón	60.9	3.14	1.2	.340	.72	21.0	33.5	0.85	1.727	.037	.110	.667	39.5
Pejibaye (b)	*Guilielma Gasipaes* (HBK.) Bailey	Peach palm	Guápiles	59.0	3.10	1.4	.446	1.64	40.4	44.3	2.23	.290	.038	.154	.917	14.8
Piña (a)	*Ananas comosus* (L.) Merrill	Pineapple	Alajuela	86.4	0.03	0.5	.083	.33	7.8	5.7	0.27	.017	.062	.029	.148	39.6
Piña (b)	*Ananas comosus* (L.) Merrill	Pineapple	Near Cartago	85.2	0.04	0.2	.065	.39	29.8	5.8	0.59	.002	.071	.035	.288	22.1
Sandía	*Citrullus vulgaris* Schrad.	Watermelon	Near Puntarenas	93.8	0.06	0.1	.068	.23	3.2	7.6	0.30	.007	.022	.023	.181	7.8
Sapote	*Licania platypus* (Hemsl.) Fritsch.	Sapote	Alajuela	64.6	0.26	2.5	.291	1.61	33.2	24.5	0.52	.157	.005	.027	1.530	35.6
Tacaco	*Polakowskia Tacaco* Pittier	Tacaco	Alajuela	.....	.....	...	.302	.67	8.9	52.7	0.93	.052	.026	.130	.....	23.3
Yas (a)	*Persea Schiedeana* Nees	Yas	Cartago	63.9	16.54	1.2	.353	.71	8.9	42.8	0.64	.130	.095	.152	.897	5.5
Yas (b)	*Persea Schiedeana* Nees	Yas	Near Cartago	69.2	10.37	1.0	.229	.76	11.3	28.4	0.59	.034	.053	.106	.645	15.1
Zapote (a)	*Calocarpum mammosum* (L.) Pierre	Sapote	Near Orotina	55.3	0.60	1.9	.231	1.28	55.9	27.9	1.03	.051	.004	.011	1.591	11.5
Zapote (b)	*Calocarpum viride* Pitt.	Green Sapote	Near Alajuela	69.5	0.28	1.6	.283	1.38	35.7	23.6	0.74	.031	.011	.027	1.880	49.9

TABLE 2 (*Concluded*)

Composition of Food Samples From Costa Rica

Name of food sampled			Place of origin of sample	Constituents measured and yields per 100 gm.											
Spanish	Scientific	English		Moisture	Ether extract	Crude fiber	Nitrogen	Ash	Calcium	Phosphorus	Iron	Carotene	Thiamine	Riboflavin	Niacin	Ascorbic Acid-Total
				gm.	*gm.*	*gm.*	*gm.*	*gm.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*
	DRY SAMPLES															
	1. Cereals															
Arroz	*Oryza sativa* L.	Rice	Turrúcares	11.3	0.26	0.2	1.813	0.48	5.3	109.5	1.56	.006	.084	.038	1.794	.....
Maíz blanco	*Zea Mays* L.	Maize, white	Liberia	11.9	3.09	1.3	1.816	1.40	6.2	319.0	2.21	.009	.504	.129	1.700	.....
Maíz de Guinea	*Sorghum vulgare* Pers.	Kafir corn	Turrúcares	15.9	0.50	1.5	2.014	1.79	11.6	427.0	3.52	.019	.590	.415	4.035	.....
	2. Legumes															
Cubá blanca	*Phaseolus coccineus* L.	Scarlet runner bean	Cartago	15.8	1.39	5.1	3.665	3.56	108.7	310.8	10.82	.013	.242	.107	2.365	.....
Cubá amarilla	*Phaseolus coccineus* L.	Scarlet runner bean	Cartago	11.3	1.59	5.0	3.605	4.30	146.3	345.2	9.95	.014	.358	.113	1.753	.....
Frijol de arroz	*Phaseolus calcaratus* Roxb.	Rice bean	Alajuela	10.5	0.89	4.2	3.189	4.37	399.8	272.0	6.45	.032	.663	.104	1.940	.....
Frijol bainica	*Phaseolus vulgaris* L.	Bean	Puriscal	10.7	0.74	4.3	4.054	4.26	162.0	562.0	7.20	.004	.555	.150	1.105	.....
Frijol b'anco	*Phaseolus vulgaris* L.	White bean	Santa Ana	11.9	0.97	4.5	4.118	3.83	138.0	416.0	6.84	.011	.485	.187	1.952	.....
Frijol chileno	*Phaseolus vulgaris* L.	Small red kidney bean	Santa Ana	10.8	0.96	4.3	3.966	3.37	126.0	426.5	6.07	.028	.434	.165	2.030	.....
Frijol chimbolo	*Phaseolus vulgaris* L.	Black bean	Santa Ana	11.6	1.09	4.6	4.519	4.29	117.4	518.0	8.32	.028	.547	.112	1.805	.....
Frijol guaria	*Phaseolus vulgaris* L.	Bean	Santa Ana	10.4	0.86	4.3	3.668	3.62	110.5	388.0	6.29	.015	.354	.141	2.235	.....
Frijol higuerillo	*Phaseolus vulgaris* L.	Bean	Santa Ana	9.1	0.79	4.9	3.754	4.15	210.3	515.5	6.60	.024	.589	.146	1.379	.....
Frijol Jamaica	*Phaseolus vulgaris* L.	Bean	Santa Ana	9.6	1.14	3.2	3.615	3.79	121.8	477.6	10.37	.011	.384	.161	2.170	.....
Frijol kuibra	*Phaseolus vulgaris* L.	Small red bean	Near Santa Ana	15.3	1.01	4.0	3.771	3.66	106.7	441.0	6.40	.013	.486	.148	2.371	.....
Frijol de mantequilla	*Phaseolus vulgaris* L.	Bean	Near Santa Ana	11.7	1.26	3.1	4.080	3.55	121.5	438.0	8.30	.013	.496	.150	2.005	.....
Frijol negro corriente	*Phaseolus vulgaris* L.	Common black bean	Near Santa Ana	9.2	0.76	4.3	4.830	4.02	118.3	531.5	7.28	.030	.466	.196	3.284	.....
Frijol norteño	*Phaseolus vulgaris* L.	Bean	Near Puriscal	10.4	1.22	5.1	3.467	3.49	103.5	284.6	5.37	.015	.345	.150	1.853	.....
Frijol de ojo negro	*Vigna unguiculata* (L.) Walp.	Cowpea	Puriscal	11.7	1.03	4.8	3.885	3.04	77.0	314.0	9.54	.040	.703	.167	1.064	.....
Frijol parranda	*Phaseolus vulgaris* L.	Bean	Near Santa Ana	11.2	1.41	4.5	3.660	3.87	162.0	295.0	5.73	.019	.454	.203	2.607	.....
Frijol portoto	*Phaseolus vulgaris* L.	Bean	Near Santa Ana	11.8	1.22	3.4	3.846	3.48	109.3	418.5	7.69	.009	.312	.129	1.945	.....

Frijol portugués	*Phaseolus vulgaris* L.	Portuguese bean	San Isidro del General	12.9	1.18	4.0	4.060	3.99	151.5	498.2	6.29	.010	.427	.153	1.340	.....
Frijol ravisa	*Vigna unguiculata* (L.) Walp.	Cowpea	San Isidro del General	7.9	0.83	5.0	3.819	3.60	83.5	459.0	6.49	.016	.895	.149	1.480	.....
Frijol Sangre de Cristo	*Phaseolus vulgaris* L.	Bean	San Isidro del General	11.1	1.73	4.0	4.225	3.66	120.0	395.5	5.78	.017	.456	.165	1.585	.....
Pisque	*Phaseolus vulgaris* L.	Bean	Near Santa Ana	9.9	1.24	3.8	4.073	3.30	74.8	308.0	5.40	.024	.427	.190	2.371	.....
	3. Berry														
Café en grano	*Coffea arabica* L.	Coffee bean	Near Tres Ríos	9.9	8.97	20.3	2.109	3.50	98.8	150.3	3.29	.017	.284	.083	1.471	.....
	MISCELLANEOUS														
Rábano de caballo	*Armoracia lapathifolia* Gilibert	Horse radish	Cartago	65.1	0.20	2.2	.631	1.75	116.8	97.0	2.73	.025	.197	.075	.462	110.0
Ruibarbo (a)	*Rheum Rhaponticum* L.	Rhubarb	San Pedro Montes de Oca	93.9	0.14	0.9	.117	1.17	92.2	20.1	0.32	.055	.015	.019	.185	8.2
Ruibarbo (b)	*Rheum Rhaponticum* L.	Rhubarb	San Pedro Montes de Oca	93.7	0.07	0.6	.078	1.01	154.9	12.6	0.37	.021	.009	.017	.130	10.8
Tapa de dulce	*Saccharum officinarum* L.	Crude sugar	Grecia	6.8	0.22	0.0	.105	1.58	32.2	29.4	4.10	.006	.017	.095	.253	.....

Flor de Itabo. This food is apparently a very rich source of ascorbic acid, judging from values obtained (498.0 and 343.0 mg.) for the two samples examined. They also contained moderate amounts of thiamine (0.182 and 0.144 mg.) and of niacin (1.578 and 1.466 mg.).

Mostaza. This leaf mustard shows no outstanding value, but contained moderate amounts of calcium (97.7 mg.) and carotene (1.723 mg.).

Pacaya is low in content of all constituents except calcium (126.1 mg.).

Perejil might be an important source of several nutrients if eaten, instead of being used merely for decoration. The sample contained important amounts of calcium (191.2 mg.), iron (14.25 mg.), thiamine (0.139 mg.), riboflavin (0.281 mg.), niacin (1.369 mg.), and ascorbic acid (143.6 mg.).

Among the Fruit Vegetables the samples of *chile dulce* are outstanding for their high content of ascorbic acid (205.3 and 236.5 mg.).

Aguacate, like many fruits, gave moderately high values for niacin (1.415, 2.164, and 1.281 mg.).

Chile picante. This hot pepper also contained a large amount of ascorbic acid (99.4 mg.), but shows no outstanding value for any other nutrient.

The two samples of *tomate* were remarkably similar in composition.

In the group of Legumes the sample of *guapinol* is outstanding in its content of niacin (4.120 mg.). It also gave high values for iron (3.24 mg.), thiamine (0.227 mg.), and riboflavin (0.173 mg.). The two samples of *alverja* and the one sample of *frijol tierno* are outstanding in their values for thiamine (0.457 and 0.316 mg., and 0.537 mg., respectively) and niacin (2.515 and 2.090 mg., and 1.845 mg., respectively).

A number of the Fruits contained appreciable amounts of niacin: *anona* (1.190 mg.), granadilla (1.481 and 1.693 mg.), *manzana rosa* (1.032 mg.), *sapote* (1.530 mg.), *zapote (Calocarpum)* (1.591 mg. and 1.880 mg.). Reference has already been made to the content of niacin in *aguacate.* The *anona* also contained moderate amounts of thiamine (0.119 mg.) and riboflavin (0.175 mg.).

Fresa. The two samples contained relatively large and very similar amounts of ascorbic acid (69.5 and 71.2 mg.).

Higo. The content of iron in the two samples (2.12 and 4.09 mg.) was considerable, although there is a marked difference between the two values.

Marañón. This so-called fruit is apparently very rich in ascorbic acid, judging from the values obtained for the two samples examined (166.5 and 200.3 mg.).

Mora. The value for the iron content of this berry is very high (19.50 mg.). Consideration must be given, however, to the question of whether this was on or in the fruit.

Pejibaye. One sample contained moderate amounts of carotene (1.727 mg.) and ascorbic acid (39.5 mg.), and the other of iron (2.25 mg.) and riboflavin (0.154 mg.). In the description of this fruit it was noted that the second sample was a cooked product.

DRY SAMPLES:

Among the Cereals, *maíz de Guinea* shows high values for nitrogen (2.014 gm.), iron (3.52 mg.), thiamine (0.590 mg.), riboflavin (0.415 mg.), and niacin (4.035 mg.).

Arroz shows moderately high values for nitrogen (1.813 gm.), iron (1.56 mg.), and niacin (1.794 mg.).

Maíz blanco, like *arroz,* shows moderately high values for nitrogen (1.816 gm.), iron (2.21 mg.), and niacin (1.700 mg.), but the content of thiamine was high (0.504 mg.) and of riboflavin considerable (0.129 mg.).

There were 21 dry samples classified as Legumes. All gave high values for nitrogen, calcium, iron, thiamine, riboflavin, and niacin. The nitrogen values were fairly uniform, ranging from 2.688 to 4.830 mg. Calcium values show significant variations. Those for 15 samples of *Phaseolus vulgaris* and the two samples of *Phaseolus coccineus* were within the range 103.5 to 210.3 mg., while that for the one sample of *Phaseolus calcaratus* was high, 399.8 mg.; and those for the two samples of *Vigna unguiculata* and one sample of *Phaseolus vulgaris* much lower, 77.0, 83.5, and 74.8 mg. Iron values came within the range of 5.37 to 10.82 mg., with those for the two samples of *Phaseolus coccineus* being uniformly high, 10.82 and 9.95 mg. Thiamine values for all except the two samples of *Vigna unguiculata* and the one of *Phaseolus calcaratus* came within the limits 0.242 to 0.589 mg. Values for these three samples were somewhat higher, 0.703 and 0.895 mg., and 0.663 mg., respectively. The range for riboflavin values was 0.107 to 0.203 mg. and for niacin values 1.064 to 3.284 mg., with no genus or species characterized by high or low values.

MISCELLANEOUS:

Among the Miscellaneous items none is of particular interest because of a high content of any nutrient. The one sample of *rábano de caballo* contained moderate amounts of calcium (116.8 mg.), iron (2.73 mg.), thiamine (0.197 mg.), and ascorbic acid (110.0 mg.), and the one sample of *ruibarbo,* moderate amounts of calcium (154.9 mg.).

SUMMARY

During March, 1948, under somewhat difficult circumstances, and March and April, 1949, 154 samples of food plants were purchased in Costa Rica. These were analyzed for content of moisture, ether extract, crude fiber, nitrogen, ash, calcium, phosphorus, iron, carotene, thiamine, riboflavin, niacin, and ascorbic acid, and the data are presented.

The foods that may be considered good sources of one or more constituents are treated in the discussion. A few of the foods for which there were more than one sample showed significant variation in nutritive content from sample to sample. These results are also discussed.

Several of the samples gave inordinately high values for certain constituents. *Raíz* contained a large amount of iron. This food is rather expensive, however, and might not be an important source of this element. *Flor de Itabo* gave very high values for ascorbic acid. These flowers are highly prized as food and although eaten cooked they might supply important amounts of vitamin C. The nutritive value of *perejil* has already

been pointed out in a previous report, Munsell *et al.* (1950c). Findings from the present study give added evidence to the possible value of this food as a source of several nutrients. *Chile dulce* gave high values for ascorbic acid and since it is frequently eaten raw, as in salads, it undoubtedly often makes a significant contribution to the diet. Two samples of *marañón* were examined. Both gave high values for ascorbic acid. The "fruit" as eaten out of hand should supply this vitamin in abundance. The one sample of kafir corn, *maíz de Guinea,* shows high values for iron, thiamine, and riboflavin, and a very high value for niacin. Probably influence should be brought to bear to increase use of this food in the diet of man. The tiny rice bean, *frijol de arroz,* seems to be an excellent source of calcium and to contain relatively large amounts of thiamine.

Attention is called to the fact that many fruits contain important amounts of niacin.

ACKNOWLEDGMENT

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RELATION OF CONCENTRATION OF CANNED TOMATO PRODUCTS TO STORAGE LOSSES OF ASCORBIC ACID[1]

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Tomatoes, both canned and fresh, are a highly acceptable source of ascorbic acid. Because of their high water content, however, unconcentrated tomato products present problems in transportation and storage, especially during war.

Concentrated tomato pastes were observed, repeatedly, to lose ascorbic acid more rapidly than did the unconcentrated tomatoes or juice. Data here reported were obtained during a search for the reason for this loss. The reviews of Maclinn and Fellers (1938) and of Hamner and Maynard (1942) were of particular value in providing general background material on tomatoes.

MATERIALS AND METHODS

The products studied are listed (Table 1).

Commercial Lot I, which included solid-pack tomatoes, juice and paste, was obtained directly from four different packers. Brands A, B, and C were sampled and put into storage soon after canning, but Brand D had four months' storage during the winter before the "initial" values were obtained. Sample B-2 was known to have been in contact with copper equipment during preparation.

Commercial Lot II was purchased early in March—presumably from the pack of the preceding year—and therefore also had from four to five months' storage before the "initial" analysis. Identification marks on the cans of each brand were identical. Glass containers introduced an additional variation in processing. This lot was sampled after shorter storage periods than Lot I.

Some samples from each commercial lot were stored at room temperature 20 to 25°C. (68 to 77°F.) and some at 37°C. (99°F.).

Experimental Lot I products were prepared from one sample of Concord tomatoes of average size, processed as nearly as possible under home-canning conditions. *Solid-pack* tomatoes were dipped in boiling water, rinsed in cold water, peeled, and cored. They were then boiled for

[1] This work was undertaken as a part of the project "A Study of the Effect of Dehydration on the Nutritive Values and Quality of Foods" under the direction of Dr. Agnes Fay Morgan, and supported in part by the Office of Scientific Research and Development, Committee on Medical Research, under Contract OEM-cmr-225, 1942-1945.

Data are taken from a thesis presented by Miriam Hummel, in partial fulfillment of the requirements for the degree of Master of Science in Home Economics at the University of California, Berkeley, February, 1947.

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10 minutes in an open kettle, placed in sterilized pint jars, and processed for 35 minutes in a boiling-water bath.

Tomatoes for *juice* were washed, cored, quartered, and softened by boiling five to 10 minutes. They were then put through an aluminum strainer. A portion of the extracted juice was canned and processed for 10 minutes in boiling water.

Concentrated juice (sp. gr. 1.035) was prepared by further boiling of the extracted juice in an open kettle.

TABLE 1

Description of Tomato Products Studied

Lot	Source[1]	Products	Container	Concentration of total solids[2]	Ascorbic acid initial value
	Packer			*pct.*	*mg./100 gm.*
Commercial I	B	Solid-pack	No. 2½ tin	6.8	17.3
	C	Solid-pack	No. 2½ tin	6.5	17.1
	D	Solid-pack	No. 2½ tin	6.6	21.1
	A	Juice	No. 2 tin	(7.3)	17.0
	C	Juice	No. 2 tin	6.3	16.1
	A	Paste	6-oz. tin	28.5	66.0
	B	Paste—1	6-oz. tin	32.3	78.3
	B	Paste—2	6-oz. tin	32.3	86.2
	B	Paste—3	6-oz. tin	26.8	69.5
	C	Paste	6-oz. tin	28.6	54.0
Commercial II	E	Paste	12-oz. glass	26.2	71.4
	F	Paste	6-oz. tin	26.1	58.5
Experimental I	L	Solid-pack	Pint glass	6.8	18.1
		Juice	Pint glass	6.6	20.6
		Conc. Juice	Pint glass	8.9	26.3
		Purée	Pint glass	14.9	42.4
		Paste	Pint glass	32.5	85.0
Experimental II	L	Juice	½-pint glass	7.3	21.0
		Juice diluted from paste	½-pint glass	7.8	19.5
		Juice fortified with ascorbic acid and Cu**	½-pint glass	7.9	70.8
		Paste	½-pint glass	28.6	82.0

[1] L = laboratory product.

[2] Average of all samples tested. Variations in total solids between the cans for a given product of any one brand were highest (15 per cent) in the one juice sample in parentheses. Some samples varied from five to 10 per cent, but most variations were less than five per cent.

Purée was made by concentrating the rest of the juice under reduced pressure. A portion of this was placed in a dehydrator and concentrated to *paste*. Both purée and paste were canned at boiling temperature in sterilized jars and not subjected to further processing. These samples were stored at 32°C. (90°F.) only.

Experimental Lot II was prepared from tomatoes of the Stone variety. Juice was extracted as for Experimental Lot I and stored temporarily at refrigerator temperature. Some was concentrated to a paste in glass containers under reduced pressure. "Reconstituted" juice was prepared by

diluting some of this paste with water redistilled from glass. Part of the original juice was fortified with ascorbic acid [3] and copper [4] to equal approximately the concentration of these constituents in the paste.

In order to compensate for ascorbic acid loss during the time required for the concentration and analyses, extra ascorbic acid [3] was added at the time of canning, to raise the concentration to the levels representative, respectively, of a good juice or a good paste. For the juice, the added ascorbic was 40 per cent of the total present, for the juice diluted from paste 83 per cent, and for the paste 72 per cent. The juice fortified to paste concentration with ascorbic acid and copper had 93 per cent of the vitamin in added form.

All samples in this lot were brought to boiling temperature and canned in sterilized half-pint glass jars with slightly concave glass tops. These were filled as completely as possible. Most of the samples of juice were processed for five minutes, but a few samples were given a processing time of 20 minutes, in order to determine whether the probable removal of extra air would facilitate increased vitamin retention on storage. Processing times for paste were 10 and 45 minutes, respectively.

A few samples were held at room temperature and the rest in the incubator at 37°C. (99°F.). The temperature in this incubator sometimes increased to 39°C. (102°F.) during the last half of the storage period. Periodical analyses of all lots were made as indicated, one jar or can being taken at a time.

Analytical Methods: Total solids were determined in Commercial and Experimental Lots I by drying to constant weight in a vacuum oven at 70°C.(158°F.). The A.O.A.C. method (1945) was employed for Lots II. A glass electrode assembly was used in making the pH determinations.[5]

The colorimetric method used to determine ascorbic acid was essentially that of Loeffler and Ponting (1942) with the modifications noted below. Usually 30 gm. of tomatoes or juice, or from 10 to 15 gm. of paste, were blended in a Waring Blendor with one per cent metaphosphoric acid for two or three minutes. The resulting mixture was made up to 250 ml. with additional metaphosphoric acid. In cases where the extracts showed fading while in the colorimeter, readings were taken at five-, 10-, 15-, and 30-second intervals. The degree of fading was seldom very noticeable except for some samples stored for a long period at 37°C.(99°F.), or in some of the dehydroascorbic acid analyses. Adjustment was made by subtracting the five- to 10-second difference from the five-second reading as recommended by Hochberg, Melnick, and Oser (1943). Some aliquots of the tomato extracts were also titrated against the sodium 2,6-dichlorobenzenoneindophenol dye, which had been standardized according to Menaker and Guerrant (1938).

Dehydroascorbic acid was determined by bubbling hydrogen sulfide for 15 minutes through 10 ml. of the sample solution, which then stood for two hours or overnight in stoppered 50-ml. centrifuge tubes. After

[3] "Roche" U. S. P. crystalline vitamin C.

[4] $CuSO_4 \cdot 5H_2O$, C.P.

[5] This was made available through the courtesy of the Division of Food Technology.

wet nitrogen had been bubbled through the sample from one to three hours, the resulting total reduced ascorbic acid was determined.

Copper analyses were made according to a method developed by several workers and outlined by Greenleaf (1942), with some modifications as given by Bohart (1940). Since Experimental Lot II was not exposed to bismuth, cobalt, or nickel, the procedure for removal of these elements was omitted. Juice samples of 100 gm., or paste or fortified juice samples of 25 gm., were digested with nitric and sulfuric acid and made to 100 ml. in volumetric flasks. A 20-ml. aliquot of each was removed to a 250-ml. separatory funnel, as described by Bohart, and correspondingly larger amounts of reagents than those recommended by Greenleaf were subsequently added. Final solutions were read in an Evelyn photoelectric colorimeter, using a 440-mμ filter, and compared with standards ranging from zero to 30 μg. prepared from electrolytic copper. Suitable blanks were made.

RESULTS AND DISCUSSION

Ascorbic acid retention during storage of the commercially prepared products is shown (Figs. 1 and 2), and for the experimental material (in Figs. 3 and 4, and Table 2).

Commercial Samples: Before storage, on the basis of dry weight, the highest values for ascorbic acid in pastes were equal to those for the unconcentrated tomatoes. The lowest was about 25 per cent below them.

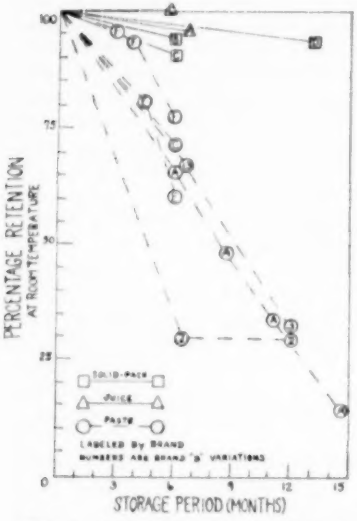

FIG. 1. Percentage retention of ascorbic acid in commercial canned tomato products, Lots I and II, stored at room temperature.

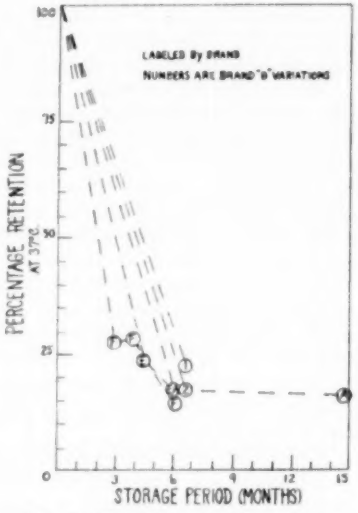

FIG. 2. Percentage retention of ascorbic acid in commercial canned tomato paste, Lots I and II, stored at 37°C. (99°F.).

Retention was calculated on a wet weight and reduced ascorbic acid basis.

For comparison, percentage retentions were computed on a wet weight basis, since the variation in solids in some samples was appreciable. It was assumed that ascorbic acid, because of its solubility, would be distributed fairly evenly between the material which might settle out during canning and the liquid portion.

At room temperature two brands of solid-pack tomatoes retained 91 to 94 per cent of their ascorbic acid after six months, and one brand had 94 per cent of the amount in the original sample after storage for 13 months. Two brands of tomato juice had as good or better retention than the solid-pack. Paste samples, on the other hand, had kept an average of only two-thirds of their ascorbic acid for six months and a scant one-third at the end of a year. As might be expected, the paste sample which had been in contact with copper equipment during processing had lost ascorbic acid rapidly.

Increased storage temperatures accelerated the rate of loss of ascorbic acid in all paste samples studied. After six months at 37°C.(99°F.) average retention of reduced ascorbic acid was only 20 per cent. Samples analyzed after shorter periods of storage indicate this low value was approached after only three to four months.

Analyses for dehydroascorbic acid were made on some of the commercial samples. No appreciable amount was found in the solid-pack or juice after storage. Only traces were found in pastes after six months at room temperature. When low ascorbic acid values were reached (after a year at room temperature for one sample, and from three to six months at 37°C. for several others tested), dehydroascorbic acid was apparently present as an additional 65 per cent of the low value for the former, and 15 to 45 per cent for the others. This would not increase the total value to a very appreciable extent. Because of the continued fading of the dye observed during colorimetric determination, occasionally of ascorbic and often of dehydroascorbic acid, in the paste samples stored for a long time, particularly at high temperatures, it is probable that data for these samples represent maximum approximations, rather than true values. This also applies to the experimental lots when ascorbic acid had reached low values.

The possibility that ferrous ions from the cans might be interfering with the determination seemed small, because apparent values became progressively lower as storage was continued. Bessey's test (1944) for interfering substances was negative when applied to some miscellaneous commercial samples, including a few of the above. Definite interference was demonstrated for one stored paste, which had the low apparent value of seven mg. per cent ascorbic acid.

Color comparisons were made for Brand E and F pastes stored at 37°C. Brownish discoloration was evident after three to four months, especially in Brand E, and was quite marked in both samples after six months.

Measurements of pH made after four or four and one-half months' storage were 4.14 and 4.12 for Brand E at room temperature and at 37°C., respectively, and 4.17 and 4.13 for Brand F.

The high retention figures for ascorbic acid found for the unconcentrated products, canned in tin and kept at room temperature, are in

agreement with or slightly higher than those noted by numerous other workers. There have been comparatively few reports on ascorbic acid in tomato pastes, and none show specifically the effect of storage on these concentrates. Some investigators, Izmrudova (1934), Soloveichek (1935), Aschehoug (1934 and 1935), have reported appreciably lower values for tomato purées and pastes than might be expected, considering the high ascorbic acid values of fresh tomatoes. Rauen (1942) found about 65 per cent retention of ascorbic acid in Italian tomato products concentrated to various degrees. Lo Coco (1943) obtained a range of 78 to 120 mg. per cent in pastes prepared by his company and presumably analyzed shortly after preparation.

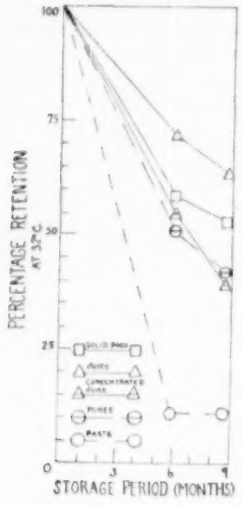

FIG. 3. Percentage retention of ascorbic acid in experimental canned tomato products, Lot I, stored at 32°C.(90°F.).

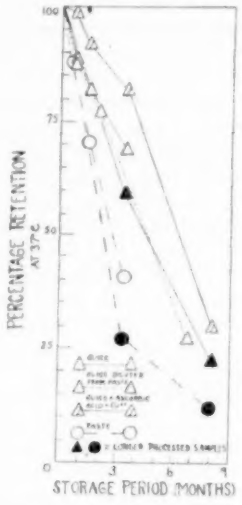

FIG. 4. Percentage retention of ascorbic acid in experimental canned tomato products, Lot II, stored at 37°C. (99° F.).
*Value determined was 103 per cent.

Retention was calculated on a wet weight and reduced ascorbic acid basis.

Experimental Material: Lot I was used to compare storage losses of ascorbic acid in products prepared from the same batch of tomatoes. Canned tomatoes and juice in this lot prepared in the laboratory gave, before storage, ascorbic acid values equal to or higher than those for the commercially prepared samples, while the paste value was within the commercial range.

As may be seen (Fig. 3), ascorbic acid was best retained by the juice. Retentions at six and at nine months were 72 and 63 per cent, respectively. Comparable retention figures for solid-pack tomatoes were 59 and 53 per cent. Dehydroascorbic analyses on the stored solid-pack samples averaged an increase of seven per cent above the reduced value. Slightly-concentrated juice had 55 per cent retention at six months, but only 39

per cent at nine months. Dehydroascorbic added 15 and 10 per cent, respectively, above the reduced value. These dehydroascorbic acid percentages are based on the reduced value of the stored sample. The purée kept 51 and 41 per cent of its ascorbic acid, whereas the paste had only 11 per cent after six months. The paste had an additional 50 per cent of this value as dehydroascorbic, and this apparent level was maintained for some time. However, as noted in connection with the stored commercial pastes, there is considerable doubt whether all the substance measured was actually ascorbic acid.

These are figures for products processed largely by methods used in the home, canned in glass and stored at 32°C.(90°F.). They showed a consistent increase in the percentage loss of ascorbic acid as the concentration of the product increased. This effect was the same as that noted for tinned commercial products. These determinations indicated that this loss occurred, regardless of method of processing or type of container. Obviously, the next step was to find the constituent or constituents which reached levels destructive to ascorbic acid as a result of the concentration.

In Experimental Lot II (Table 2), both juice and paste retained comparable amounts of ascorbic acid after 14 weeks at room temperature, but when stored at 37°C. for 14 weeks the juice retained 68 per cent of its ascorbic acid and the paste only 40 per cent. Most of the samples in this lot were stored at 37°C.

That the process of concentration did not in itself result in formation of a substance which caused destruction of ascorbic acid, was indicated by the fact that the juice made from diluted paste lost about the same amounts of ascorbic acid during storage at 37°C. as the plain juice (Fig. 4).

When copper sulfate was added to juice fortified to paste concentration with ascorbic acid, the destruction of the vitamin represented a lower percentage loss than in the plain juice. The concentration of copper as determined by analysis in representative jars of the fortified juice was close to the average value for the paste. This would seem to rule out the increased content of copper as a significant factor causing storage losses.

An estimate was made of the amount of oxygen which could be present in the headspace of the glass jars, in order to determine to what extent this might account for the storage loss. One ml. of air at 25°C. (77°F.) furnishes about 0.27 mg. of oxygen. Maximum headspace in jars used was calculated as 20 ml. ($\pi r^2 \times \text{depth} = 3.14 \times 3.17^2 \times 0.635$ cm.). This amount of oxygen could oxidize to dehydroascorbic acid only about one-third the ascorbic acid in a half-pint jar of paste. Since the jars were filled and sealed just below boiling temperature, the amount of headspace oxygen present must have been considerably less than that so calculated. However, observed losses of ascorbic acid have exceeded this calculated maximum.

The possibility of occluded air was not considered in this calculation. However, reduction of dissolved air by increasing the processing time of the samples did not increase the amount of ascorbic acid retained. The juice fortified to paste level with ascorbic acid also lost more of this vitamin than could be accounted for by headspace oxygen. Results would

TABLE 2

Retention of Ascorbic Acid in Experimental Canned Tomato Products, Lot II, After Storage

Product	Process time	Storage temp.	Storage period	Total solids	Ascorbic acid	Dehydro-ascorbic acid[1]	Ascorbic acid retention[2]	Copper	pH[3]
	min.	*°C.*	*wk.*	*pct.*	*mg./ 100 gm.*	*pct.*	*pct.*	*p.p.m.*	
Juice	5	.....	0	7.29	21.0	.....	.....	.....	.....
	5	Room	15	7.34	15.9	8	76	.....	(4.24)
	5	Room	34	7.34	10.9	Trace	52	.64	4.25
	20	Room	34	7.34	11.7	7	(56)	.48	4.28
	5	37	3	7.39	18.5	Trace	88	.....	(4.22)
	5	37	6.5	7.26	17.1	0	81	.....	.....
	5	37	14	7.27	14.4	15	68	.....	(4.22)
	20	37	14	7.27	12.4	.....	(59)	.....	.....
	20	37	34	7.39	4.6	30	(22)	.52	4.26
Juice diluted from paste	5	.....	0	7.81	19.5	0	.....	.....	.....
	5	37	3	.....	17.0	0	87	.....	(4.22)
	5	37	8	7.82	15.0	6	77	.....	.....
	5	37	30	7.81	5.1	15	26	.48	4.25
Juice fortified with ascorbic acid and copper	5	.....	0	7.75	70.8	5	.....	.....	.....
	5	Room	15	7.75	65.9	8	93	.....	.....
	5	37	3	8.22	73.0	Trace	103	.....	(4.17)
	5	37	6	7.80	65.0	5	92	2.15	.....
	5	37	14	7.78	57.8	Trace	82	.....	(4.21)
	5	37	34	7.91	20.5	Trace	29	1.91	4.25
Paste	10	.....	0	28.5	82.0	Trace	.....	.....	.....
	10	Room	15	28.7	63.9	5	77	.....	.....
	10	37	3	28.5	71.4	0	87	.....	(4.19)
	10	37	6.5	28.6	57.0	3	70	1.90	.....
	10	37	14	28.6	32.6	15	40	1.71	(4.19)
	45	37	14	30.0	22.5	.....	(27)	.....	(4.11)
	45	37	34	30.0	9.3	40	(11)	2.24	3.99

[1] The dehydroascorbic acid figures are stated as per cent above, and are based upon the corresponding reduced ascorbic acid value. They were seldom large except when the reduced ascorbic acid figure was low.

[2] Calculated on reduced ascorbic acid values, wet weight. Data in parentheses are calculated on the basis of original figures for the shorter processing times, and so may have had, actually, a higher per cent retention.

[3] Values in parentheses were determined after samples had been opened and stored in refrigerator for periods ranging from four and one-half to six months.

indicate that available molecular oxygen could not entirely account for the destruction.

Acid concentration was suggested as a destructive factor by the change in color from red-orange to brownish-red when losses of ascorbic acid were marked. Hamner and Maynard (1942) gave the range of pH for tomatoes as 4.0 to 4.5. Lo Coco (1945) and Bohart (1940) gave average values of 4.32 to 4.38 for round tomato varieties, and 4.44 to 4.47 for the San Marzano or pear-shaped varieties. Lo Coco (1943) gave a pH of 4.16 as an average figure for 45 samples of tomato juice.

In five brands of commercial pastes, opened after varying storage periods, pH measurements made during the present study ranged from 4.13 to 4.23, with an average of 4.17. Unfortunately, facilities for measuring pH were not available until some of the stored samples of Lot II

had been opened and refrigerated for some time. Values for the juice samples which were freshly-opened averaged about 4.26. Other juice samples measured after being opened and stored in the refrigerator for various intervals showed slight increases in acidity. It seems fair to conclude, therefore, that the acidities of the edible paste samples in Lot II did not exceed, and were probably less than, the figures given, 4.19 and 4.11 (Table 2), even though one dark brown, freshly-opened sample, after eight months at 37°C., gave a reading of 3.99. If a pH of 4.15 represented the acidity of the paste, the difference of about 0.1 pH between it and the juice would mean the hydrogen-ion concentration of the paste was approximately one and one-fourth that of the juice. This variation is no greater than that noted for different commercial samples of juice, or than variety differences noted in fresh tomatoes.

While this difference in pH does not seem great enough in itself to account for the instability of the ascorbic acid, the fact that it is the result of increased concentration of weakly-ionized acids and their salts, means it reflects a much greater difference in molar concentration of these acids. On the basis of total solids, normality of citric acid in paste may be calculated as four times that in the juice (or increasing toward five, for some commercial variations). If some reaction involved in the destruction or inactivation of ascorbic acid follows mass law, this increased concentration might be significant. The browning of the stored paste suggests a change involving a compound present in greater amount than the ascorbic acid.

SUMMARY

After six months' storage at room temperature, the percentage loss of ascorbic acid in three brands of commercially-canned tomato paste averaged over three times that observed for solid-pack tomatoes and tomato juice. After a year's storage, two brands of paste had lost 70 per cent of their ascorbic acid. At 37°C. the pastes lost ascorbic acid more rapidly. After four months, less than 30 per cent was left, and after six months less than 20 per cent.

When tomato products of varying concentration were prepared from the same lot of tomatoes and canned in glass in the laboratory, storage loss of ascorbic acid increased with increases in concentration. Unconcentrated tomatoes and juice stored at 32°C. retained about 60 to 70 per cent of their ascorbic acid after six months, while paste kept only 11 per cent.

Paste prepared from juice in the laboratory and then diluted back to juice concentration lost no significantly greater percentage of its ascorbic acid after storage for several months at 37°C., than did juice which had not undergone the concentration process.

Tomato juice fortified with ascorbic acid and copper to paste concentration showed no greater percentage loss of ascorbic acid than did juice alone.

The possible effect of air occluded in the paste or present in the headspace is discussed.

Measurements of hydrogen-ion concentration gave slightly higher acid figures for pastes than for juices. The differences were, however, no greater than the variations given in the literature for different samples of juice

or varieties of tomatoes. Molar concentration of citric acid, as calculated from differences in total solids, was about four and one-half times as great in the paste as in the juice. The possibility that this may contribute to the instability of the ascorbic acid in the paste is discussed.

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LEUCONOSTOC MESENTEROIDES AS THE CAUSE OF ROPINESS IN CANNED PEACHES

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Ropy fermentation is often encountered in the different food industries. It occurs most often in the dairy and sugar industries. The cause of ropiness, as determined by investigators, has been bacterial in origin.

In the fall of 1949, the Michigan Agricultural Laboratory, Lansing, Michigan, submitted samples of canned peaches in which the syrup had become ropy. Bacteriological analysis was made of the samples and representative colonies were picked from the plates. Cultures so obtained were purified and identified according to the methods outlined in "The Manual of Methods for Pure Culture Study of Bacteria."

LITERATURE REVIEW

For the sake of brevity the different foods in which ropiness has been found and the organisms causing the ropiness have been listed (Table 1).

ISOLATION AND IDENTIFICATION OF *LEUCONOSTOC MESENTEROIDES*

Streaks were made on tomato juice agar and on yeast extract-glucose agar from the samples of ropy peaches obtained from the Michigan Agricultural Laboratory. The yeast extract-glucose agar gave the best growth, so this medium was used for the isolation of the organism. Yeast extract-glucose agar plates were streaked and single colonies were picked and streaked on another series of yeast extract-glucose agar plates. This was repeated six times. Further to insure purification of the organism, single colonies were picked from the sixth plate and inoculated into 15-ml. vials of yeast extract-glucose broth. The vials were well shaken and allowed to stand 20 minutes. Streaks were then made on yeast extract-glucose agar plates. The dilution of a single colony in 15 ml. of yeast extract glucose broth and the subsequent streaking gave greater assurance of the isolation of a pure strain. In this manner 11 pure strains were isolated and run through the different tests for identification. The Manual of Methods for the Pure Culture Study of Bacteria (1948) recommends that a minimum of six isolates of the organism, to be identified, be run through the different tests for identification.

A Gram stain of the organism was made from a 24-hour yeast extract-glucose broth culture. The stain showed gram-positive cocci or very short rods in pairs or short chains.

Colonies 24 hours after streaking on yeast extract-glucose agar were uniformly round, pinpoint, translucent, raised, dome-shaped, granular, and entire.

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TABLE 1

Foods in Which Ropiness Has Occurred, and Causative Organisms

Food	Causative organism	References
Milk and/or milk products	*Bacterium* (15 species)	Buchanan and Hammer (1915)
Milk and/or milk products	*Bacillus* (9 species)	Buchanan and Hammer (1915)
Milk and/or milk products	*Micrococcus* (5 species)	Buchanan and Hammer (1915)
Milk and/or milk products	*Streptococcus* (4 species)	Buchanan and Hammer (1915)
Milk	*Alcaligenes viscosus*	Beck and Chase (1938)
Milk	*Pseudomonas*	Davis (1935)
Milk	*Corynebacterium*	Davis (1935)
Milk	*Bacillus mesentericus vulgatus*	Flügge (1893)
Milk	*Lactobacillus casei*	Hammer (1948)
Milk	*Lactobacillus bulgaricus*	Hammer (1948)
Milk	*Aerobacter aerogenes*	Hammer and Hussong (1931)
Milk	*Micrococcus cremoris viscosi*	Hammer and Cordes (1920)
Milk	*Streptococcus pyogenes* or *Streptococcus lactis*	Hess and Borgeaud (1888)
Milk	*Bacillus vulgatus*	Hueppe (1884)
Milk	*Micrococcus pituitoparus*	O'Droma and Grimes (1941)
Milk	*Escherichia neapolitana*	Sarles and Hammer (1933)
Milk	*Aerobacter cloacae*	Sarles and Hammer (1933)
Milk	*Bacillus lactis viscosus*	Ward (1899)
Milk	*Micrococcus* (thermoduric)	Prouty (1943)
Cream	*Sarcina aurantica*	Rodenkirchen (1939)
Cream	*Alcaligenes viscosus*	Hammer (1948)
Cream	*Streptococcus lactis*	Buchanan and Hammer (1915)
Chocolate milk	*Micrococcus* or *Achromobacter*	Tarnutzer (1939)
Whey	*Streptococcus lactis*	Hammer (1948)
Whey	*Alcaligenes viscosus*	Hammer (1948)
Tea	*Aerobacter aerogenes*	Greene, Judd, and Marx (1940)
Sauerkraut	*Lactobacillus cucumeris*	Pederson (1930, 1931)
Sauerkraut	*Lactobacillus plantarum*	Pederson (1930, 1931)
Maple sap	*Bacillus aceris*	Edson (1910)
Maple sap	*Bacillus parallelus*	Edson, Jones, and Carpenter (1912)
Maple sap	*Pseudomonas fluorescens*	Edson, Jones, and Carpenter (1912)
Maple syrup	*Aerobacter aerogenes*	Fabian and Buskirk (1935)
Cucumber brine	*Achromobacter* and involution forms of *Leuconostoc*	Fabian and Nienhuis (1934)
Bread	*Bacillus panificans*	Laurent (1885)
Bread	*Bacillus mesentericus vulgatus*	Kratschmer and Niemilowicz (1889)
Bread	*Bacillus mesentericus vulgatus*	Russell (1898)
Bread	*Bacillus panis*	Fuhrman (1905)
Bread	*Bacillus subtilis* like organisms	Allen (1919)
Meat curing sol'ns	*Micrococcus lipolyticus*	Horowitz-Vlasova and Livshitz (1931)
Sausage	Unnamed cocci	Schroder (1930)
Sugar cane juice	*Leuconostoc mesenteroides*	Hucker and Pederson (1930)
Sugar beet juice	*Leuconostoc mesenteroides*	Kircher (1839)
Sugar beet juice	*Leuconostoc mesenteroides*	Feltz (1874)
Sugar beet juice	*Leuconostoc mesenteroides*	Jubert (1874)
Root beer	*Leuconostoc mesenteroides*	Benedict (1948)
Canned pineapple	*Leuconostoc mesenteroides*	Spiegelberg (1940)

A can of peaches was obtained and macerated in a sterile Waring Blendor. The macerated peaches and their juice were placed in small flasks and autoclaved. After autoclaving the flasks were inoculated with the isolates. Ropiness developed in all flasks in 48 hours. The ropy strings when stretched reached about one-half inch or more before breaking. A Gram stain revealed the same gram-positive cocci in pairs or chains.

Morphological characteristics of the isolates: gram-positive cocci 0.95 to 1.3 μ. in diameter, occurring in pairs or short chains, non-motile, and aerobic.

TABLE 2

Carbohydrate Utilization of the Organisms Isolated From Canned Peaches

Carbohydrate	Isolates [1]											Gas production
	1	2	3	4	5	6	7	8	9	10	11	
Xylose	a	a	a	a	a	a	a	a	a	a	a	–
Arabinose	a	a	a	a	a	a	a	a	a	a	a	–
Dextrin	a	a	a	a	a	a	a	a	a	a	a	–
Maltose	a	a	a	a	a	a	a	a	a	a	a	–
Galactose	a	a	a	a	a	a	a	a	a	a	a	–
Lactose	a	a	a	a	a	a	a	a	a	a	a	–
Rhamnose	–	s	–	–	s	s	s	–	–	s	–	–
Mannose	–	–	–	–	–	–	–	–	–	–	–	–
Raffinose	–	a	a	a	a	a	a	a	a	a	a	–
Dextrose	a	a	a	a	a	a	a	a	a	a	a	–
Inulin	–	–	–	–	–	–	–	–	–	–	–	–
Manitol	–	–	a	–	–	–	–	–	–	–	–	–

[1] Key: a = acid production, s = slight acid production, and – = negative production.

Cultural characteristics: on gelatin stab slight surface growth and no liquefaction; on agar slants, small, round, pinpoint, transparent, raised, and dome-shaped colonies; on yeast extract-glucose agar (24 hours), round, pinpoint, translucent, raised, dome-shaped, granular, and entire colonies; turbidity in yeast extract-glucose broth.

The physiological characteristics: no reduction of litmus milk; indol test negative, nitrates not reduced to nitrites, and acetylmethylcarbinol not formed in the Voges-Proskauer test; acid but no gas in xylose, arabinose, dextrin, maltose, galactose, lactose, raffinose, glucose, and sucrose; very slight acid and no gas in rhamnose, glycerol, and starch; no acid or gas in mannose, inulin, and manitol.

Checking the characteristics with Bergey's Manual of Determinative Bacteriology (1948), the organism to which the above characteristics most nearly corresponded was *Leuconostoc mesenteroides*. The only difference noted was that no acid was produced from mannose.

SUMMARY

L. mesenteroides was shown to be the causative organism of ropiness in samples of canned peaches.

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